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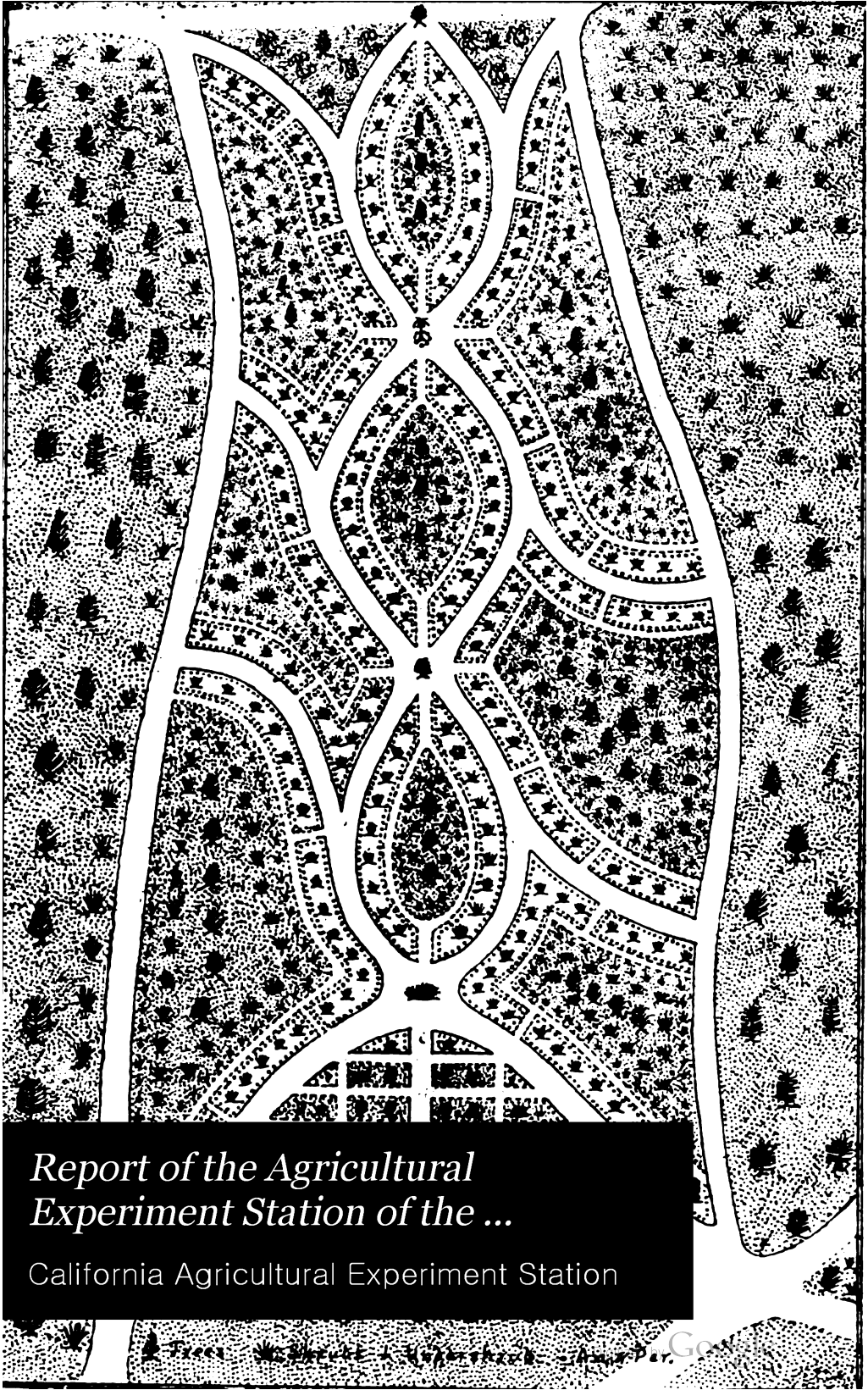

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AGRICULTURAL EXPERIMENT STATION.

REPORT

ON THE

AGRICULTURAL EXPERIMENT STATIONS

OF THE

UNIVERSITY OF CALIFORNIA,

WITH

DESCRIPTIONS OF THE REGIONS REPRESENTED.

By E. W. HILGARD,
Professor of Agriculture and Director of the Station.

BEING A PART OF THE COMBINED REPORTS FOR 1888 AND 1889.

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LETTER OF TRANSMITTAL.

President HORACE DAVIS:

DEAR SIR: I transmit herewith for publication a report on the experiment stations established under the auspices of the University under the "Hatch Bill," including descriptions of the physical and agricultural features of the regions represented by them; and in case of the Central Station at Berkeley, a historical statement both of its origin, and, summarily, of the work it has heretofore accomplished. As the enactment of the bill creating a national endowment toward the carrying on of agricultural experimentation in the several States inaugurates a new era in this work, both in California and in the country at large, a somewhat full review of what has been accomplished up to the time when that law went into effect seems both appropriate and necessary in order to put the facts on record while they are within reach. Among other points which it is of some interest to record, is that the University of California was the first to officially establish an agricultural experiment station within the United States.

As stated by me in a report made to you last year, the extra duties imposed upon me in the establishment of the outlying sub-stations have made it impossible for me to issue either bulletins or reports that required my personal attention, until after the relief granted me by the Board of Regents in May last went into effect. As a consequence the reports are now so far behindhand that it seems best to consolidate those for the years 1888 and 1889 into one, to be issued as fast as my regular current duties will permit; not the completion of the whole, but of such parts as will form compact subdivisions by themselves. On this plan the following publications have already been made:

1. *Reports of Experiments on Methods of Fermentation, and related subjects.* 1888; 48 pages.

2. *Report of the Professor in charge to the President.* 1889; 19 pages. (This report treats of instruction, experimental work, and the establishment of the new stations.)

3. *Report of Examinations of Waters, Water Supply, and related subjects.* 1889; 57 pages.

The report transmitted herewith will, therefore, be the *fourth* installment of the joint reports, and is to be followed by two others, viz.: The record and discussion of the viticultural work done since the last report was issued; and of miscellaneous cultural, entomological, and laboratory work not included in the present document. It is hoped that these will be ready by the end of the present session, or sooner.

It is for the reason that the viticultural work could not be at present included that detailed reference to the three viticultural stations is now omitted; since such reference would of necessity lead to discussions for which the record is not fully completed or digested.

I have thought it proper to add to the report, as an appendix, a discussion of the methods and general results of the soil investigations that have formed a considerable part of the work of this station from the beginning. The fact that such work is now urgently needed by many of the stations,

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and is likely to be carried on by the United States Geological Survey as a portion of its regular operations, while few are familiar with its methods, render this publication timely.

Very respectfully,

E. W. HILGARD,
Professor of Agriculture and Director of Experiment Station.

BERKELEY, April 7, 1890.

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EXPERIMENT STATIONS

OF THE

UNIVERSITY OF CALIFORNIA.

GENERAL CULTURE STATIONS:

The Central Station, Berkeley, Alameda County.

The Foothill Station, near Jackson, Amador County.

The Southern Coast Range Station, near Paso de Robles, San Luis Obispo County.

The San Joaquin Valley Station, near Tulare City, Tulare County.

VITICULTURAL STATIONS (under private auspices):

Cupertino, Santa Clara County.

Mission San José, Alameda County.

Fresno, Fresno County.

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THE CENTRAL EXPERIMENT STATION.

Location: Berkeley, Alameda County.

The experiment station at Berkeley is the direct outgrowth of experimental work begun, in connection with the College of Agriculture of the University of California, shortly after the transfer of the institution from its first location, in Oakland, to the present and permanent site. The location of the station was therefore not determined by selection for that purpose, but by its connection with the University, which was designedly placed within easy reach of the city of San Francisco. It thus happens that it represents, climatically, only a comparatively limited area, and is better adapted to the propagation of a wide range of vegetation, than to culture experiments of wide applicability; but this, as well as the great uniformity of temperature through the year, renders the Berkeley station peculiarly well suited to the needs of *general* experimentation, as the center of experimental work in the State. It admits of the growth and propagation, out of doors, of plants widely apart in their climatic adaptations, and on that account under disadvantage as regards fruiting, but not otherwise under stress. The northern currant and the semi-tropic citrus and dragon trees flourish here side by side, and with a little protection even many intertropical plants can be kept in fair condition. This relieves in a measure the need of large plant houses and other expensive appliances, and facilitates approximate culture experiments within a very wide range. There are probably few localities in which a botanical garden might embrace so great a variety of growths of all climates, in the open air.

*History of the Berkeley Station.**

The idea of providing for the work of an agricultural experiment station prevailed at the organization of the College of Agriculture of the University of California. In 1870, Professor E. S. Carr, in an address at the State Fair, made the following specific allusion: "The University proposes to furnish the facilities for all needful experiments; to be the station where tests can be made of whatever claims attention."

Ex-President Gilman, in his report dated December 1, 1873, alludes to progress in this work, as follows: "The University domain is being developed with a view to illustrate the capability of the State for special cultures, whether of forests, fruits, or field crops, and the most economical methods of production. It will be the station where new plants and processes will be tested and the results made known to the public. * * * A fine estate has been provided, well adapted to the establishment of an experiment station in agriculture, a botanic garden, an arboretum, etc."

As is usual in the history of new undertakings, progress at first was slow and hesitating. The report for the years 1873–75, by R. E. C. Stearns, at that time Secretary of the Board of Regents, shows that forty acres were prepared for planting with a view to agricultural experiments in 1874; and that during the winter following there were planted five hundred and

*The historical and cultural details of the Central Station have been supplied by Mr. E. J. Wickson, Superintendent of the grounds.

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eighty-four named varieties of tree fruits, seventy-three of grapevines, and ninety-five of various small fruits. The purpose of such plantation, as described in Mr. Stearns' report, was as follows: "To furnish means of correcting the nomenclature of the fruits already in cultivation, and for supplying hereafter scions and plants for distribution throughout the State, as well as for the introduction of new varieties." This anticipation of the value and importance of the standard orchard of the station has been largely realized, as will be shown later in this report.

The introduction and cultural tests of economic plants of the temperate and semi-tropic regions were specially designated by the Board of Regents at the organization of the college and the establishment of the experiment station in 1870. In 1873 there were over five hundred specimens of native and foreign shrubs and trees growing on the grounds of the University. Seeds were sought from all sub-tropical countries, and especially large collections of eucalypti and acacias were obtained from Australia.

From year to year since that time new plants have been obtained by donation and purchase. Data concerning the success or failure of these plants may be found in the reports and bulletins of the station.

In 1874 buildings were erected on the grounds set apart for agricultural experiments, viz.: a barn thirty-six by forty-four feet; a tool house sixty-four by twelve feet; two propagating houses, one sixty-four by fifteen feet, the other thirty by twenty-four feet; a house for hatching fish eggs; and in addition to these larger structures a complement of sheds and outbuildings, hotbeds and cold frames was provided. Propagation of shrubs and trees from seed obtained abroad and especially from other arid regions of the world was first undertaken, and a foundation was thus laid for the arboretums on the station grounds, which are being continually extended in area and variety of growths.

In 1874 E. W. Hilgard was chosen Professor of Agriculture. In the winter of 1875–6 the first field experiments were undertaken, to determine the effects of deep culture and of the application of various fertilizers.

In 1875 the laboratory branch of the experiment station work was inaugurated, the Regents making provision for the expenses thereof for the first two years; and at the end of this time, the Legislature opened the way for the continuation and extension of the work, by liberal special appropriations from year to year. For the records of accomplishment in this important branch of station work, reference must be had to the biennial reports.

In September, 1878, the Regents set apart a piece of ground for the establishment of a "garden of economic plants," as suggested in Professor Hilgard's early reports. The tract comprised about one and five eighths acres, and it was planted during the ensuing winter with a large collection of grasses and forage plants, cereals, textiles, medicinal plants, vegetables, shrubs, trees, etc., the selection being based upon the known or anticipated economic importance of the growths chosen.

In 1878 experimental work in viticulture and wine making was begun as a special branch of investigation; and in 1880 a small experimental cellar and laboratory were constructed with funds specially appropriated for that purpose by the Legislature. This branch of work was largely extended and improved facilities provided for it from year to year, as the viticultural reports of the station show.

From 1880 until the winter of 1888, the work of the station proceeded regularly—extending its old features and assuming new ones, as will be shown in the proper connections hereafter, the needed funds being provided, both by special legislative appropriations and by increased apportionment from the general funds of the University—until at the latter date, funds

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became available under the Act of Congress known as the "Hatch law," establishing experiment stations in each State. This was an exceedingly important enactment for our station, because the work had outgrown the space and facilities which could be spared for it in the older University buildings. Its requirements in work exceeded the compass of the old force of assistants, and improved facilities for field, garden, and greenhouse cultures were also imperatively demanded. The addition of the United States funds to those hitherto available from the University resources, also made possible the establishment of outlying culture sub-stations, of which Professor Hilgard had early seen the need, and which he had advocated in his reports and public addresses for the previous decade.

The most obvious results thus far attained by the realization of funds from the Hatch law are: The increased force and vastly extended and improved facilities at the Central Station at Berkeley, and the establishment and equipment of the outlying stations.

General Climatic and Topographic Features of the Bay Region.

The "bay region" constitutes a climatic as well as a hydrographic and topographic feature; for, insignificant as the break formed by the Golden Gate may seem, it modifies profoundly the climate of the country lying adjacent and opposite to it, not only by the influence of its cool tide water, but as well by the correspondingly cool lower air currents sweeping through it almost throughout the season, and carrying with them both the temperature and the moisture of the ocean, both modified by the cold Alaskan current. In summer, the river of fog, a mile and a quarter wide and from six hundred to fifteen hundred feet high, may be seen flowing in steadily through the Gate in the afternoon, first submerging the city of San Francisco, and then broadening and sending off branches right and left up and down the bay, and toward evening reaching the opposite shore, where the Contra Costa Range forms a barrier for a time. Eventually this is surmounted, and finally the cloudy ocean may reach as far as Mount Diablo, where it dissolves before the dry air of the Great Valley. The direct influence of this current extends about ten miles each way on the opposite shore, causing an exceptionally low summer temperature, which fails to ripen the grape and the fig. On the western shore of the bay the high ranges of the immediate coast form a barrier not surmounted by a considerable proportion of the summer fogs; under the lee of these a warmer summer temperature prevails on the bay-shore slopes of the counties of San Mateo and Marin, as well as on both shores of the southern portion of San Francisco Bay, toward San José. The cold currents strike across San Pablo Bay into the lower part of Napa and Sonoma Valleys, but are chiefly deflected so as to form a steady and sometimes hard "blow" through the Straits of Carquinez, beyond which they enter the Great Valley and form the regular "up-valley" winds of that region.

Back of the bold promontory that narrows the passage from San Pablo into San Francisco Bay, begins the sloping plain (and in part the marsh belt) that skirts the eastern bay-shore from San Pablo to San José, forming, with the corresponding plain lying south of San Francisco on the western shore, an important and thickly populated agricultural region. Opposite San Francisco this slope is about three miles wide, falling about three hundred feet from the foot of the Contra Costa hills. Southward it widens to seven or eight miles on either shore, a tide marsh belt of varying width striking the bay shore; and the two belts, finally uniting at the lower end of the bay, form the broad and fertile Santa Clara Valley, so noted for

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its charming climate and the production of fruit and wines. Here the summer fogs, having to surmount the high coast mountains, are much diminished, both in frequency and in coolness, and the vine, fig, and almond attain great perfection.

The Climate of Berkeley.

The climate of Berkeley, by its proximity to the ocean, is in its main features that of the coast, but it is modified and ameliorated locally by its varying topography. The experimental grounds, by virtue of their elevation and environment, are to a certain extent protected from the intrusion of the harsher coast weather conditions of the summer season, and from the severe frosts which sometimes visit the lower levels of the district in which it is situated. On the other hand, it does not enjoy the summer heat which ripens the grape and the fig in other parts of the bay region. It is important, therefore, to characterize briefly the leading features of the local climate in which the experiments on the University agricultural grounds are carried on. Meteorological observations have been recorded, under the direction of the Department of Civil Engineering and Astronomy, at the observatory upon the University grounds, for the last four years, and the data of the immediate location, so far as available, are given below:

	1886.	1887.	1888.	1889.	1890.
Mean temperature of spring	.....	49.83	53.80	55.77	.....
Mean temperature of summer	.....	57.70	61.27	59.17	.....
Mean temperature of autumn	.....	58.43	58.53	59.50	.....
Mean temperature of winter	48.57	48.73	50.20	45.03	.....
Maximum temperature	.....	98.50	90.00	87.20	.....
Minimum temperature	.....	31.30	24.90	33.50	.....
Mean relative humidity	.....	84.34	83.22	83.37	.....
Lowest relative humidity	.....	68.07	61.68	66.18	.....
Rainfall, July to following June	.....	20.46	17.48	18.84	*43.75

*To April 1st.

To secure, at this time, data covering a more considerable period, recourse is had to the observations by Dr. J. B. Trembly, in the city of Oakland, about four miles distant from the station grounds. From Dr. Trembly's records the following statement is deduced:

Meteorology of Oakland, showing Approximately the Climate of Berkeley.

	1876.	1877.	1878.	1879.	1880.	1881.
Mean temperature of spring	54.46	55.18	55.73	56.15	52.97	56.35
Mean temperature of summer	60.40	61.17	59.36	60.07	58.95	60.27
Mean temperature of autumn	57.75	57.67	56.92	56.73	55.86	54.78
Mean temperature of winter	48.20	50.39	50.12	47.60	45.38	51.10
Maximum temperature	97.00	96.00	84.00	93.00	89.00	87.00
Minimum temperature	30.00	30.00	27.00	27.00	29.00	31.00
Mean relative humidity	83.00	81.00	84.71	85.29	83.70	83.25
Lowest relative humidity	40.00	34.40	38.60	39.00	27.00	29.00
Rainfall, July to following June	28.55	12.36	32.33	23.55	23.84	31.34

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METEOROLOGY OF OAKLAND—Continued.

	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Mean temperature of spring	54.12	54.63	55.59	58.08	55.06	55.29	49.39
Mean temperature of summer	60.06	61.16	61.89	61.23	61.60	60.29	55.52
Mean temperature of autumn	56.44	54.25	57.07	59.52	56.89	56.85	62.29
Mean temperature of winter	46.80	46.20	47.38	51.69	52.12	49.80	59.30
Maximum temperature	84.00	103.00	88.00	89.00	91.00	101.00	91.00
Minimum temperature	30.00	25.00	28.00	27.00	30.00	31.00	26.00
Mean relative humidity	82.57	83.71	85.39	86.74	87.15	88.53	85.83
Lowest relative humidity	28 70	33.90	38.19	41.50	26.70	41.50	56.70
Rainfall, July to following June	18.13	20.22	31.10	17.95	32.21	18.45	17.10

These records show clearly the leading characteristics of the climate under which culture experiments are made at the Central Station. Seasonal temperatures are very equable. The variation between the coldest and warmest months of the years cited has ranged from 12 to 17 degrees. At no time has the mercury fallen more than 7 degrees below the freezing point, and has reached this depression but once, while the usual minimum temperature is but 3 degrees below freezing. Thus only very tender plants are winter-killed. In fact, the prevailing low summer temperature more seriously limits the adaptability of the location to experimental fruit cultures than does the cold of winter. Fruits bloom approximately at the same date as the same varieties in the hot interior valleys, but so tardy is the growth under the low summer temperature that these varieties ripen a month or more later than in the interior, or, as in the case of late-ripening varieties, do not reach perfection at all. The same is true of other plants and trees which require high summer heat to secure large growth or excellence in fruitage. On the other hand, plants adapted to comparatively cool, moist air may thrive in Berkeley and utterly perish in the interior.

As the table shows, the atmospheric humidity sinks to a low minimum each year; but this condition prevails but for a few days at a time, while a dry, north wind is blowing; and plants which show distress (by curling of leaves, etc.) during this period, generally recover quickly under the influence of a current of moist air, which flows in from the ocean as soon as the north wind is stayed. For this reason some plants thrive here which would not survive the continued heat and drought of some interior points which perhaps do not show a lower minimum humidity.

Thermal Belts.—Among the climatic peculiarities belonging more or less to the whole State, but more especially pronounced in the valleys opening toward the bay, is the occurrence of "thermal belts," or minor regions exempt to a remarkable degree from the severer frosts of winter, but more especially from the later ones of spring, which are so dangerous to fruit about the time of bloom. These usually occur between one hundred and eight hundred feet above the valleys, varying of course with the trend and exposure to the coast winds. The difference in temperature at sunrise between these belts and the valleys sometimes amounts to as much as 10 degrees F., which, in a region where the thermometer rarely falls below 26 degrees, of course implies a very material difference in the chances of such fruits as almonds, apricots, and even the vine, and in many cases permits of the successful culture of semi-tropical fruits, such as the orange, lemon, pomegranate, etc. Thus the latter are successfully grown (*e. g.*, in certain valleys near Martinez, Contra Costa County) within two miles of the cold blast that sweeps through Carquinez Straits. Similar cases are frequent in the valleys of Napa and Sonoma; a very striking example is

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that of the Vacaville fruit belt in Solano County. In the Santa Clara Valley the culture of the almond follows narrowly a similar warm belt.

The *Soils* of this bay coast are substantially of three kinds. Immediately along the shore lies a narrow strip of sandy land, sometimes sand drifts, which influence more or less the character of the adjacent marshes; most of the soils of the latter, however, are heavy, and when reclaimed are very productive. Inland of these lies a broad belt of black, calcareous, and very fertile adobe or prairie soil, somewhat refractory in tillage, which, toward the foot of the hills, often becomes yellow and relatively poor. This adobe belt is interrupted crosswise by the sediment lands of the streams flowing from the Coast Range to the bay. These lands have generally light soils, and are often of considerable width, although few of these streams are now of much importance; but the frequent shifting of their channels in past times has increased the alluvial surface. These sediment soils frequently, of course, pass gradually into the adobe proper, and are noted for their productiveness; they furnish much of the market supplies of the two cities in fruits and vegetables, but are more especially noted for the high quality of brewing (Chevalier) barley produced on them. Sugar beets likewise succeed well, but cotton fails to mature its bolls within reach of the coast fogs.

The range skirting the eastern shore, commonly known as the *Contra Costa Range*, though traversed by some abrupt cañons, has largely rounded crests and summits, and gentle slopes, with deep, and in part, very productive soils, now largely used for grazing purposes only, but susceptible of cultivation to the top. Extensive plantations of eucalyptus trees have been made on this range, and succeed admirably. The slopes originally had some redwood timber, and have now in the cañons and on the northern and eastern slopes not inconsiderable bodies of live oak (*Q. agrifolia*), madrona (*Arbutus Menziesii*), laurel (*Umbellularia Californica*), and buckeye (*Æsculus Californica*); on the banks of streams the western alder (*Alnus incana*) and maple (*Acer macrophyllum*), the buckthorn (*Frangula Californica*), with more or less undergrowth of hazel, poison oak, bramble, and others, and much eagle fern (*Pteris aquilina*).

The University Location and Domain.

The University of California is situated in the town of Berkeley, near the northern boundary of Alameda County. Its landed property consists of about two hundred acres, located at the foot of the Contra Costa hills. Its surface is diversified, and varies in elevation from two hundred to eight hundred and fifty feet above the sea level; its general slope is toward the west. The western boundary of the University grounds is about two miles distant from the eastern shore of the Bay of San Francisco; and about twelve miles directly west from the University site is the Golden Gate, the famous strait connecting San Francisco Bay with the Pacific Ocean.

Experiment Grounds of the Central Station.

That portion of the University domain exclusively devoted to the uses of the agricultural experiment station is shown in the accompanying diagram. In area it is approximately twenty-five acres, and its situation the northwest corner of the University property. The natural boundary of the tract on the east and south is a small tributary of a stream of periodic flow known as Strawberry Creek, and partly the main stream itself, which is of no economic importance except that its bed serves as a natural drain-

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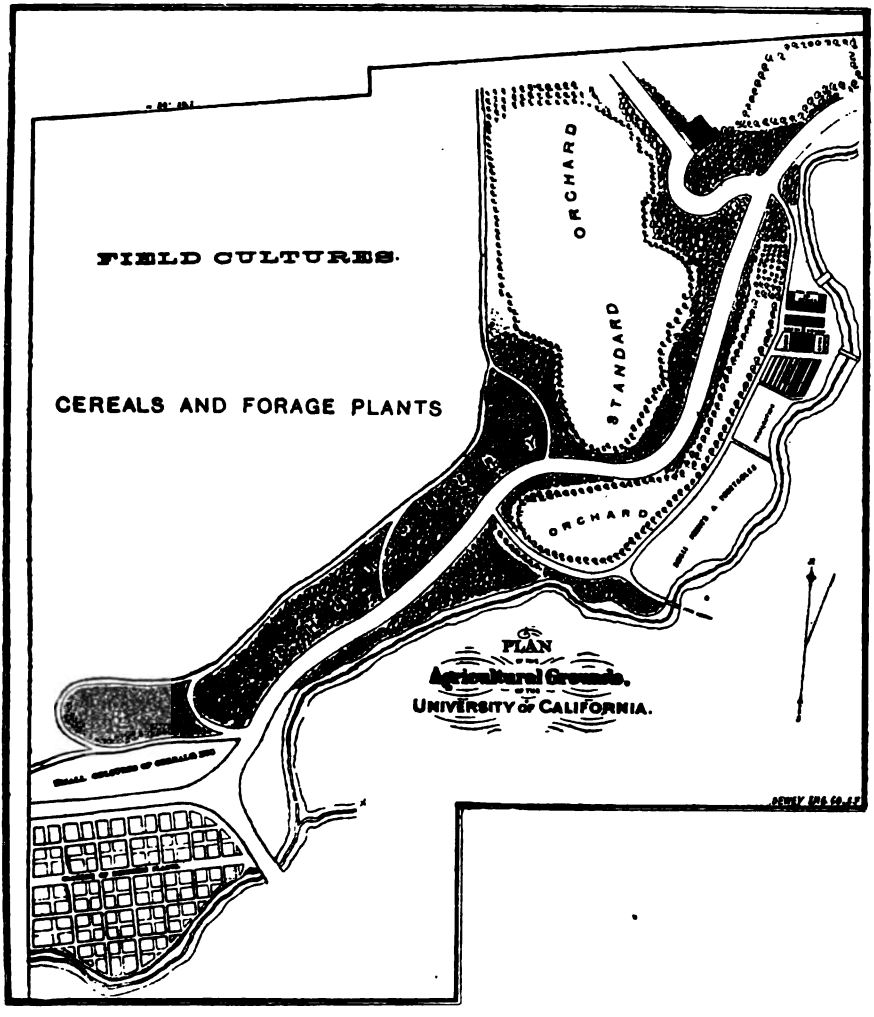

age outlet for a good portion of the tract, and its heavy winter flow brings down a good supply of gravel for the garden walks. It constitutes, however, a picturesque feature of the grounds, and with its natural border-growth of oaks, laurels, buckeyes, and shrubs, must be regarded as a most desirable feature.

The lowest part of the tract is the Garden of Economic Plants, in the southwest corner; a more elevated site for the garden would have been chosen had there been a sufficient connected area of suitable soil available. From the garden the ground rises gradually but not evenly toward the northwest, the highest point being the extreme northeast corner (as shown in the diagram), which is now occupied with a peach orchard. This elevation is approximately seventy-five feet higher than the garden. The area marked "standard orchard" on the diagram is about twenty-five feet lower than the peach orchard, has a gradual slope to the south and west, and is occupied chiefly with the collections of pears and apples. From this area

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toward the east there is a rapid slope to the southeast, upon which are growing small collections of grapevines, peaches, and nectarines, and a large collection of apricots and plums. At the base of this slope is a long, narrow strip of level creek-bottom land, devoted chiefly to nursery and propagating grounds, and the propagating and tool houses.

The larger area of the tract, as shown in the diagram, is devoted to field experiments with cereals, forage plants, fertilizers, etc., and to the growth of hay for station use. It slopes gradually to the west.

Besides the lands shown on the diagram the station has, by courtesy of the Secretary of the Board of Regents of the University, the use of several acres of hill and bench land on the east side of the University property, for experiments in forestry. Descriptions of each of the several divisions of the experiment grounds are given under the appropriate heading.

The topography of the grounds favors the quick escape of surplus water; but the nature of the soil, which is fully described hereafter, is such that in some parts of the area trees have been killed by standing water, and timely cultivation of the ground has been impossible. These evils have been remedied by underdraining with tile, and the improvement secured thereby is most marked. Up to the present time (March, 1890) there have been laid one thousand nine hundred and twenty-two feet of three-inch tile as mains and four thousand and seventy-seven feet of two-inch tile as laterals. This work has been done in the main orchard and in the "Garden of Economic Plants." The draining of portions of the lands devoted to field cultures will be accomplished during the coming summer. The drains have been cut to an average depth of three and one half feet, the tile carefully aligned and bedded in the clay subsoil, and in most cases a covering of six inches of pebbles and small cobbles gathered from the adjacent surface has been placed over the tile, this covering being overlaid with about three inches of brush or straw and the trench then filled with earth. This refuse material for covering was at hand, and the surface has been enough improved by the raking off of small stone to repay the labor in doing it. In this way underdrains have been secured which act quickly and effectively and constitute a permanent improvement. It is impossible to state accurately the cost of laying these drains, for the work was done by the regular force of the station at irregular intervals, when other duties were not pressing.

The *Orchards* of the station, to which brief references have already been made, occupy about five acres of land. In the appendix to this report may be found the full list of fruit varieties now growing. The summary is as follows:

Peaches	96 varieties.	Crab-apples	15 varieties.
Nectarines	13 varieties.	Quinces	4 varieties.
Apricots	25 varieties.	Figs	6 varieties.
Plums and prunes	75 varieties.	Japan persimmons	6 varieties.
Cherries	36 varieties.	Mulberries	6 varieties.
Almonds	7 varieties.	Miscellaneous	35 varieties.
Olives	30 varieties.		
Pears	145 varieties.	Total	636 varieties.
Apples	137 varieties.		

The Garden of Economic Plants.—This division is located in the southwest corner of the agricultural grounds adjacent to one of the chief entrances to the University domain, and is, therefore, readily accessible to visitors, among whom it is popular, especially with plant lovers, who give much time to observation of the various growths. The situation was chosen, however, rather because it was the largest available area of soil least unsuitable for the purpose. An area of free loam at an elevation would

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have been selected instead of an area of adobe in a depression, but there was no chance to exercise such preference, and the present site was accepted with the determination to make the best of it. Quite gratifying success has been attained in this effort, and by the use of lime and manure and by frequent and thorough cultivation the soil answers the requirements satisfactorily, as shown by the growths now well established; although the loss by frosts of some plants, which would have probably been saved on a more elevated site, has to be deplored.

The garden, as originally laid out, included an area of about one and five eighths acres, which was surrounded by a serviceable post, rail and wire fence. Along the bank of Strawberry Creek, which forms the southern boundary, was planted a border of exotic shrubs and low trees; along the fence, on the east and north sides, a border of a line of New Zealand flax (*Phormium tenax*), with an inner line of Esparto grasses; this has formed a very acceptable environment. The interior surface is laid out, because of the desirability of series of uniform sized areas for comparative experiments, into rectangular plots, the smallest series four by four feet, and the largest twenty-five by thirty feet, with series of intermediate areas. There were originally six hundred and eighty-eight subdivisions, but some changes have since been made according to changing needs. The classified list of perennial plants now established in the Economic Garden is given in the appendix to this report. In addition thereto a considerable area is of course given each year to annuals, including vegetables, of which no list is given, because of constant changes in the selection.

Adjacent to the inclosed area of the garden there are plots of ground of something less than an acre in extent, which are used in connection therewith. These cannot be included in the inclosure, because of the necessity of maintaining existing roadways.

The Greenhouses, Seedhouse, Nursery, Etc.—The propagating houses are situated as shown in the diagram. The buildings were erected, as previously stated, in 1874. They were of very light construction, and have only been maintained thus long by watchfulness and constant repairing. They have been for years inadequate to the needs of the station, and must soon be replaced by a more spacious structure, or, more correctly speaking, a respectable greenhouse must be provided, and existing structures used as propagating sheds. Because of lack of space and untrustworthy heating apparatus, no collection of greenhouse plants, such as visitors would expect to see in an institution of this kind, has ever been possible. Many desirable things have been donated, but have been killed by lack of adequate heat, or have been thrown out for fear of their pushing off the insecure roofing. During the last few years, both for lack of accommodations and because of the space and time demanded in the propagation of economic growths, it has been seen to be impracticable to pay attention to ornamental work. From these causes the propagation department of the station is apt to be pronounced uninteresting by the amateur, and must rest its claim to credit upon its performance in the line of multiplication and distribution of plants of prospective economic value.

During the summer of 1889 the old home-made heating arrangement for the houses was replaced by a Harvey hot-water heating outfit, which has proved a great improvement both in the volume and the regularity of heat supply.

For the last few years the station has used as a seedhouse a couple of rooms in an adjacent cottage occupied as a residence by the foreman. There is now provided a substantial, one-story building, forty-five by twenty feet, which will hereafter serve for seed storage and the exhibition

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of the collection of grains with head and stalk, fruits, etc. This building is now being fitted up with cases containing large and small drawers, large and small bins, shelving, tables, and hooks for suspension of specimen sheaves, etc. It will supply much needed accommodations in this leading line of the station work.

A small piece of bottom land adjoining the creek, as shown in the diagram, has been in continuous use as a nursery for all lines of outdoor propagation. During the last two years it has been fully employed in growing fruit trees for planting at the outlying stations, scions being taken from the standard orchards adjacent to the nursery.

The Soils of the Experiment Grounds at Berkeley.

When field experiments began under his direction in 1875, Professor Hilgard made a careful examination of the soils of the University domain, and published the following characterization of them in the report of 1877:

There are substantially three varieties of soil within the present inclosure, viz.:

1. Black adobe, more or less modified by intermixture with the hill soil; occupies a level tract adjoining Strawberry Creek, in the southwest corner.

2. Yellow clay upland soil, derived directly from the disintegration of the soft clay-sandstone forming the bedrock of the lower foothills. This somewhat intractable, and not very fertile, soil occupies most of the experimental grounds of the University, and thence reaches to the foot of the mountain slope.

3. The soil of the mountain slope proper is usually not quite so heavy, contains a large amount of powdered rock of various kinds, and when so located that it can be cultivated seems to be more productive than the preceding. It has not as yet received any detailed examination.

The record of the examination of the two soils first named is as follows:

Nos. 1 and 2. *Black adobe soil and subsoil*, taken on the University campus, in the rear of Cottages 3 and 4, half way to the bridge.

The black soil here is over thirty inches deep, underlaid by a yellow, stony subsoil. It becomes exceedingly "sticky" when wet, but plows easily when taken just at the right point of moisture; when plowed a little too wet, clots heavily, but the clods tend to pulverize in drying. With shallow tillage, or when left untilled, it forms widely gaping cracks in the dry season. If tilled deeply and thoroughly, it retains moisture and a luxuriant growth of weeds throughout the dry season, and is almost ashy in its tilth.

The soil having been sown to grain, so far as known, for many years, and worn badly, it was deemed best not to take the surface soil for analysis, but a layer from twelve to twenty-two inches depth, and then another from twenty-two to thirty inches; the latter representing the extreme probable range of crop roots.

No. 4. *Adobe ridge subsoil*, taken from the crest of the ridge on the agricultural grounds of the University, four hundred feet west-southwest from the barn; depth, ten to twenty inches.

Tint, a tawny yellow. Very heavy in working; difficult to till at all times; downwards it gradually passes into "rotten" clay sandstone (fragments of which are everywhere intermixed with the soil), at a depth varying from two and one half to five feet. It is, therefore, ill-drained naturally, holds water for a long time, and is esteemed rather a poor soil.

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Soils and Subsoils of Berkeley Station.

	No. 1. Adobe Soil. 12 to 22 inches.	No. 2. Adobe Subsoil. 22 to 30 inches.	No. 4. Ridge Adobe Subsoil.
Mechanical Analysis.			
Weight of stones over 1.2mm	13.9	35.3	13.2
Weight of stones between 1.2mm and 0.6mm	6.6	7.8	4.6
Fine earth	79.5	56.9	82.2
	100.0	100.0	100.0
Mechanical Analysis of Fine Earth.			
Clay	31.9	33.5	18.9
Sediment of <0.25mm (less than one fourth millimeter)	24.6	22.1	17.2
Sediment of 0.25mm	1.1	6.0	4.9
Sediment of 0.50mm	3.4	5.9	6.8
Sediment of 1.0mm	4.8	7.0	6.4
Sediment of 2.0mm	7.5	6.4	6.6
Sediment of 4.0mm	6.2	7.9	3.7
Sediment of 8.0mm	.9	4.0	7.4
Sediment of 16.0mm	2.8	1.8	11.1
Sediment of 32.0mm	7.7	.2	9.5
Sediment of 64.0mm	5.4	.0	3.4
	96.3	94.8	95.9
Chemical Analysis.			
Insoluble residue	77.84	69.56	86.00
Potash	.45	.34	.18
Soda	.07	.10	.15
Lime	1.05	.99	.48
Magnesia	1.21	1.91	.45
Br. ox. of manganese	.08	.09	.03
Ferric oxide	4.67	7.20	4.01
Alumina	7.79	13.97	5.53
Phosphoric acid	.23	.11	.05
Sulphuric acid	.08	.02	.02
Organic matter and water	5.72	6.60	4.05
	99.19	100.89	100.95
Humus (surface soil, 12 inches depth)	2.22		.89
Ash	.81		.56
Silica	.44		.32
Av. phosph. acid	.08		.03

To one familiar with the prairie soils of the southwestern United States, the resemblance of the "black adobe" of California to the "black prairie" of Mississippi and Alabama is very striking. The analyses given above abundantly confirm this supposition. Both the mechanical and chemical composition of the adobe is so nearly like that of the "white lime prairie" soil of Monroe County, Mississippi, that the differences are scarcely greater than might be found in different localities in either region. The conclusion is that the experience had in the cultivation of the Mississippi prairie will doubtless be found directly applicable to the black adobe of the Coast Range.

There is one difference in favor of California adobe; it is about one third richer in phosphates than the "prairie," and this explains the fact that grain crops, so exhaustive of that ingredient, have for a succession of eighteen to twenty years been grown without apparent diminution.

The fact that the black adobe contains one per cent of lime, shows that the addition of any *small* amount of lime, as a manure, would be useless—a conclusion directly confirmed by the culture experiments. But it is nevertheless true that the tillability of the soil may be greatly improved by such addition of lime as can be afforded, in cultivation on a large scale,

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as in truck gardens, orchards, flower gardens, lawns, etc. The sample analyzed probably represents pretty fairly the black adobe of the foothill slope, from San Pablo to within two miles of Oakland.

The differences in the mechanical and chemical composition of the *ridge adobe* from that of the valley is sufficiently striking. It contains less than two thirds the amount of clay, yet it is much heavier in working, owing to the small quantities of the finer sediments, which chiefly serve to break up the extreme tenacity of pure clay, that is but little disturbed by the large sized grains. Then the soil contains less than half as much lime as the lowland adobe; less than half, also, of the primarily important ingredients, potash and phosphoric acid; and, finally, very much less humus, as is shown by its tint.

The unproductiveness of this soil is clearly owing to two causes combined—it is naturally poor in plant food, and its mechanical composition makes it so refractory that it is only in exceptionally favorable seasons that what it does contain of plant food can remain available to plants, since, in drying, it becomes of stony hardness, with only cracks to aid the circulation or penetration of air and roots.

This is one of the cases in which improvement by merely supplying the plant food would be a waste of money, unless the physical condition be corrected at the same time. Underdrainage would probably do this most effectually; green manuring would also be a very important aid. But the unusually small amount of clay for so heavy a soil promises excellent results from the use of a moderate quantity of *quicklime*, or marl.

To test this conclusion, based upon the known effect of lime in rendering clays less cohesive, the following experiment was made: One hundred grammes (about three ounces) of the soil were kneaded into a paste, and allowed to dry at steam heat. Two other similar portions were similarly treated, after being mixed intimately with, respectively, one per cent and one half per cent, by weight, of quicklime, freshly slacked.

The lumps of soil dried without addition were, as might be expected, of stony hardness. Those of the portion dried with one per cent of lime, on the contrary, were so crumbly as to make it difficult to handle them without breaking them all into powder. Those of the portion containing one half per cent of lime were not quite so loose, but still resembled a very sandy soil, and were readily crumbled to a loose powder between the fingers.

Of course no such extreme change as that noted in the above experiments need be brought about in the soil of a field. This would require an extravagant outlay for lime, even at the rate of one half per cent. But even a very small fraction of the effect produced by the quantity mentioned would suffice to effect a very material improvement in the tillability of these adobe ridge soils; and in the case of truck gardens, orchards, and vineyards, the saving of labor in tillage, together with the increased thriftiness of the soil, would probably very soon pay for the outlay in the purchase of lime. The quantities needed per acre to produce a profitable result will form the subject of experiment. As regards other fertilizers, the use of phosphates and of nitrogenous fertilizers (ammonia salts or Chili saltpeter) is indicated by the analysis, for the present; for the future, potash will also be required.

This kind of "ridge adobe" seems to be of very extended occurrence in the foothills of the Coast Range, and its improvement forms a practical question of wide importance.

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The Experiment Station Building at Berkeley.

The experiment station building, like the station itself, has had a gradual growth, and owes to this circumstance its location on a lower level than the rest of the University buildings, it having been erected in part on foundations preëxisting and devoted exclusively to viticultural work. In its present form it is the outcome of the "Hatch Act," as the $3,000 allowed for buildings by the terms of that Act were, together with about $7,000 from the University fund, employed in its completion. Its total cost, including that of the basement and cellar previously existing, has been about $16,000.

Prior to the erection of the present superstructure, the agricultural department and station were extremely cramped for room, and its various branches so far separated in different buildings or stories as to render systematic work very difficult, the Director's office being in his private dwelling at an inconvenient distance. It is only now that work can, with the additional assistance provided for, be properly systematized, and the material accumulated during the past fifteen years be made accessible and useful to its full extent.

The general view of the building, on page 32, shows (as a consequence of the peculiar location) only the wooden superstructure, beneath which are a spacious brick basement, and below this, again, the cellar serving for viticultural work. Strawberry Creek flows around the rear, there being sufficient room between for the outdoor work, and a platform over the creek on which the sulphuring and washing of kegs and other large objects can be conveniently done. On this, the southern or sunny, as well as in winter the weather side, a dense grove of California laurels affords shade and protection. As will be seen from the plan of the building given below, an entrance similar to the one shown in the general view on the right (western) end of the building is placed on the left; another (double-door) entrance leads directly into the basement on the rear (creek) side, where loaded wagons can have convenient access. The vertical section of the building, on page 33, shows the relation of the several stories to each other, the dotted line representing the surface of the ground.

Interior Arrangements.—In the interior arrangements and outfitting of the building, its double object has, of course, been kept in view. While it is mainly devoted to the purposes of experimental work, yet the special agricultural instruction of the College of Agriculture is intended to be given here, because of the close and mutually advantageous relations existing between the two classes of work. The collections are equally necessary and available for both; and as the students admitted to the laboratories have as a rule gone through their elementary course in the general chemical department of the University, they usually engage in some kind of special analytical or experimental work when entering here, and thus frequently contribute important data toward the latter; while at the same time they acquire the salutary habit of logical reasoning from facts observed by themselves, which is so important a result of all original investigation.

The *Main Floor* (see diagram) has the ceiling fourteen feet high. In the several laboratories the walls and ceilings are ceiled with pine, oiled and varnished, in order to avoid the inconveniences arising from the inevitable corrosion of plaster-finished walls. The rest of the main and second floors is lath-and-plaster finished, the wood work being redwood, oil-finished. It was originally intended to give all the wood work of the laboratories two coats of soluble glass, for safety against fire; but the very dark tint assumed

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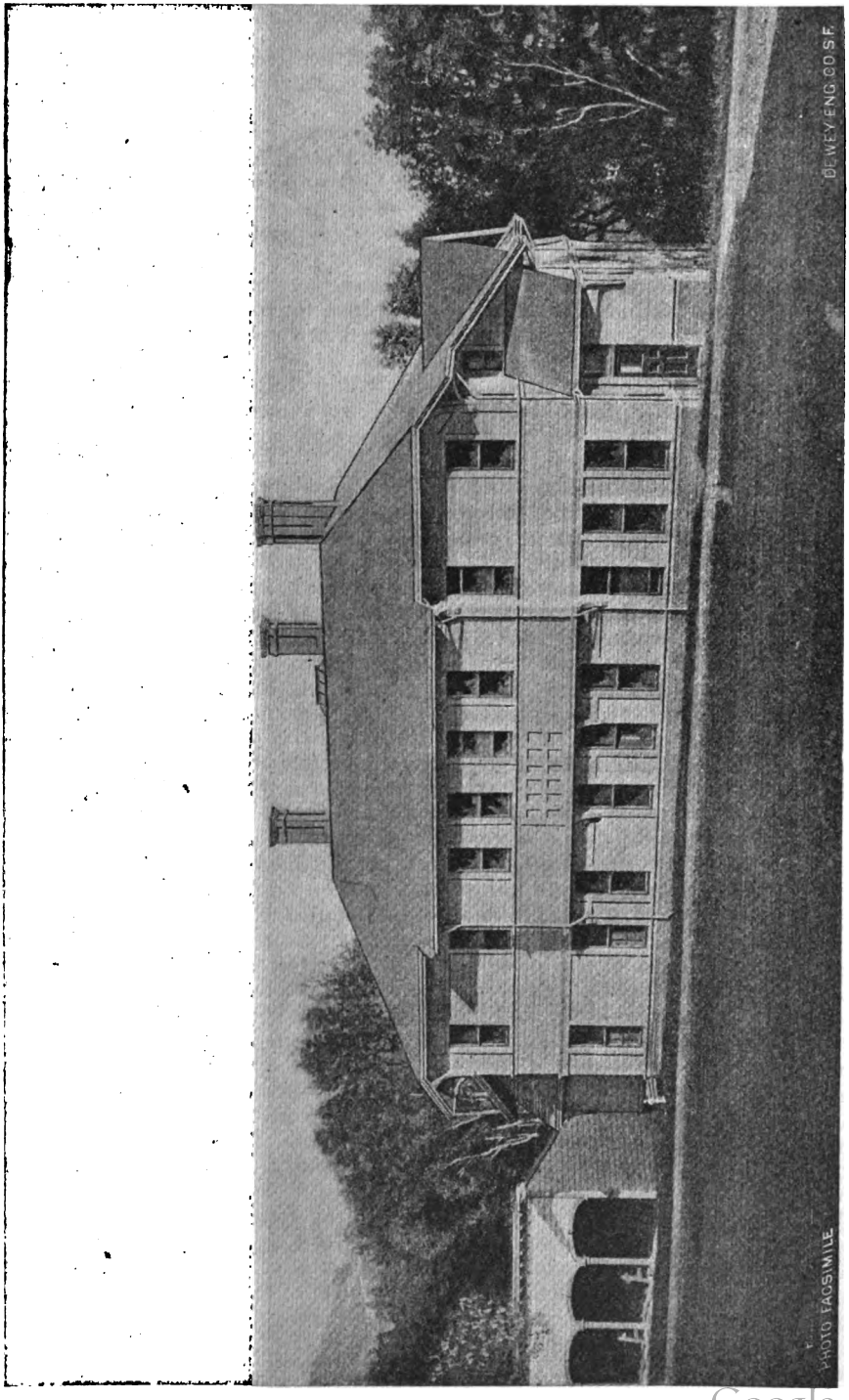

THE EXPERIMENT STATION BUILDING. (North View.)

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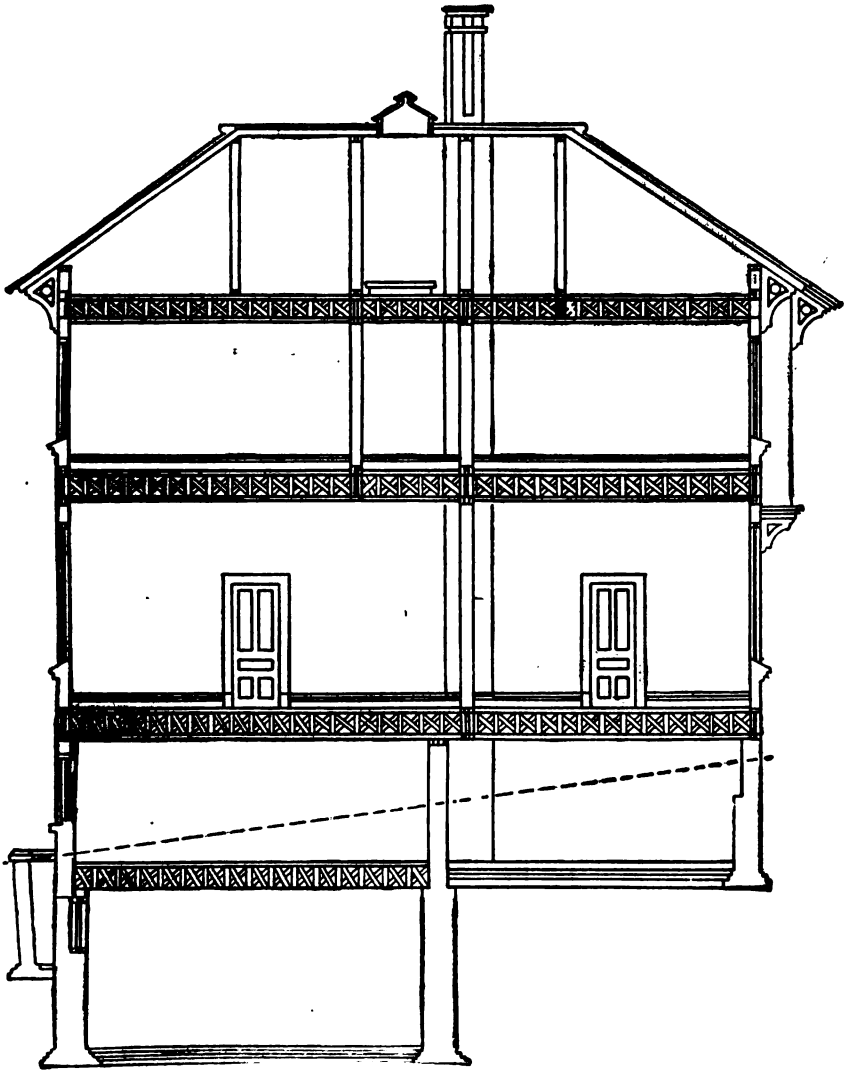

VERTICAL SECTION OF THE EXPERIMENT STATION BUILDING. (The dotted line indicates the surface of the ground.)

under that treatment by all available woods compelled the abandonment of this plan, as the rooms would thus have been rendered too dark. The laboratory niches and the frame work of the hoods have, however, been thus fireproofed, so that a Bunsen gas-flame can be made to play against them without producing anything more than smoke. The substance of the hoods themselves is thick asbestos sheet.

Work tables with closets beneath run all around the wall space that can be sufficiently lighted; they are primarily occupied by the assistants' work, but likewise afford room for students. At present, desk room for ten students is provided in the agricultural laboratory; but the accommodation can readily be increased should demand arise, by placing desks on the

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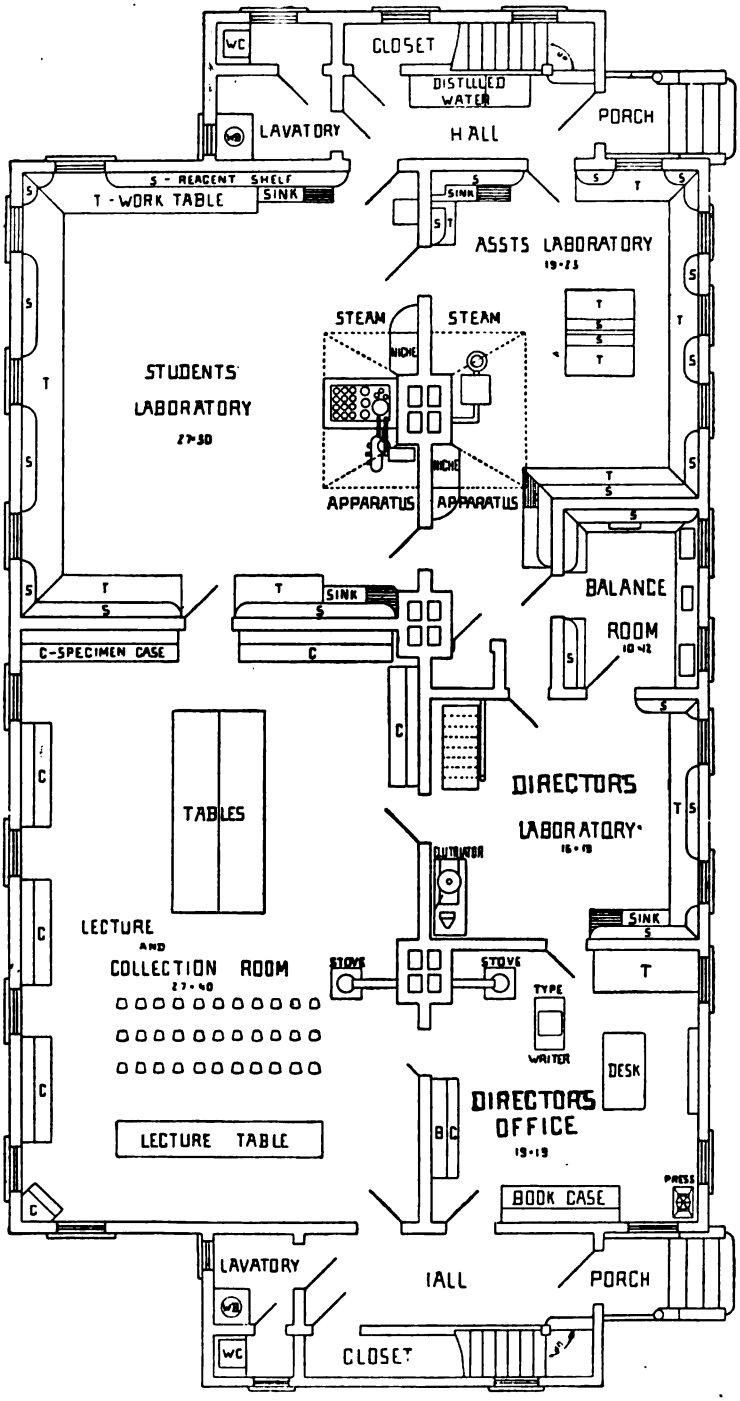

EXPERIMENT STATION BUILDING. (Main Floor.)

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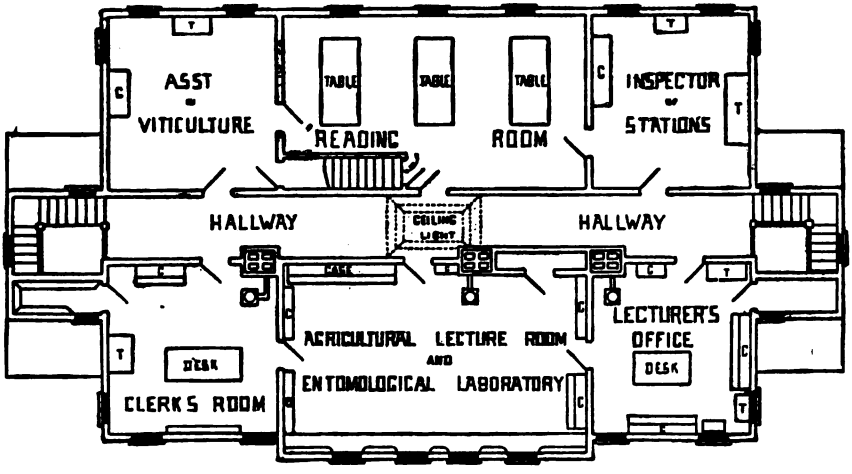
floor space remaining vacant at present. The main laboratory is provided with a "steam apparatus" manufactured according to plans furnished by the station, by the firm of F. A. Wolff & Sons at Heilbronn, Germany. It is designed specially for such work as is chiefly needed here, so as to accommodate numerous digestions, etc., at one and the same time.

The boiler is of copper, with brass top plate, into which fit steam-tight block-tin casserolles, serving as water baths, and also a fourteen-liter (three and one half gallon) block-tin still, with connections of the same material. The cooler contains three distinct block-tin condensing worms; one connecting directly with the main boiler (which can itself be used as a thirty-gallon still when the holes are closed with their appropriate covers), and supplying "ordinary" distilled water; another, with the block-tin still when used for special distillations; the third receives the purified steam that has passed through a double-walled copper drying chamber, and furnishes the "first class" distilled water for analytical use. This fundamental and indispensable appliance cost about $600 set up in place; it supplies easily, and with great economy of fuel, the distilled water needed for all purposes.

A smaller steam apparatus, heretofore used in the agricultural laboratory, occupies a corresponding place in the division more specially devoted to viticultural analysis, as indicated in the diagram. Whenever necessary the capacity of these steam baths can be readily doubled by the use of additional copper steam chests, fitted with stamped covers.

A table covered with asbestos sheet, which is again covered with sheet zinc, is under the same hood, and serves for combustions in organic analysis, for the Kjeldal nitrogen determinations, etc.

The balance room contains three Becker analytical balances, and several others for rougher weighings. It is fitted with shelves for record books, and the reference library for laboratory use.



SECOND FLOOR OF THE EXPERIMENT STATION BUILDING.

The *Second Floor*, with ceiling ten feet high, and lath-and-plaster finished throughout, is divided into six rooms; the four corner rooms being offices, while of the larger central rooms one (on the north front) is specially fitted up for a lecture room of practical agriculture, horticulture, and

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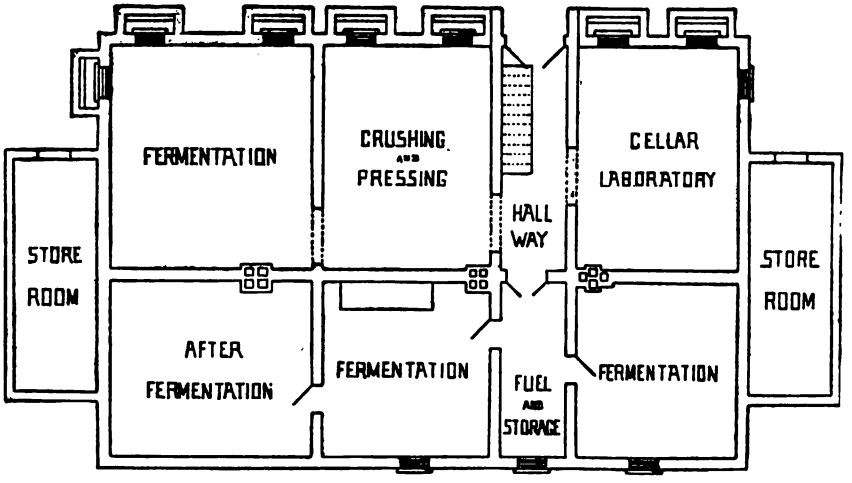
entomology; the other (south) one serves as a reading and collection room. Both, however, subserve the latter purpose, the lecture room containing the collections of cereals, seeds, insects, and other material serving for reference or the illustration of lectures, while the large room opposite is fitted to receive the library and current periodicals, as well as such other material as may overflow from the lecture room.

From the middle room on the south side stairs lead up to a spacious *Garret Floor*, lighted by a large skylight window for the present, but easily capable of having dormers thrown out if desirable. This garret is fitted with shelves around the sides, for the reception of reserve specimens and stored material of all kinds, including publications and other reserve documents. This space is particularly well adapted to the drying of plants collected, and can afford vastly increased accommodation in the future by fitting with additional shelving, tables, etc.



BASEMENT OF THE EXPERIMENT STATION BUILDING.

The *Basement* of the building (see diagram) is in the main devoted to viticultural work, except that in the laboratory room, the blast lamp for ignitions and glass work, and also the niche for the continuous distillation of pure acids, are placed. There is here, likewise, an installation for the electro-magnetic treatment of wines. The brick walls of the basement are quite heavy, and, as will be seen from the sectional view of the building, the three rooms on the north side are so nearly underground, that only transom windows, with areas sunk to the level of the ground, can be used to light them. Hence, they are well adapted to the maintenance of uniform temperatures during fermentation, and are assigned to the latter use; small coal or gas stoves, or simple gas jets, being used to regulate the warmth desired. Special closets are provided for maintaining higher temperatures for the heating of sherries, or special experiments in fermentation.

The "crushing and pressing" room is provided with three presses of different sizes; a hand-crusher, a wine-heater or "pasteurizer," sink and drain-board for washing and cleaning, bottle racks, etc. The large room adjoining is not usually used for fermentations, as erroneously indicated in the diagram, but serves as a general storeroom for the wine packages, crates, fermenting tanks, etc.

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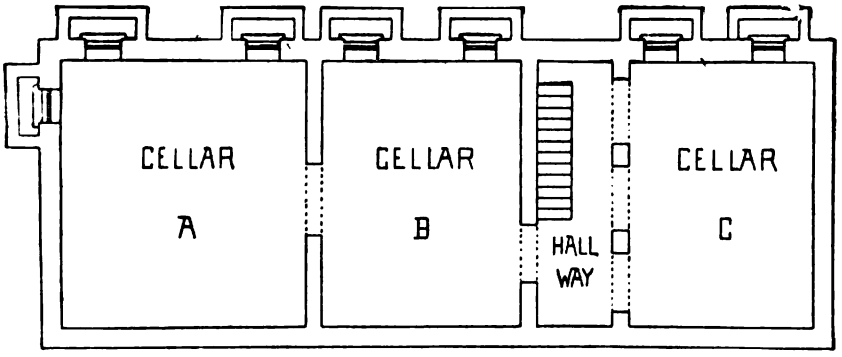

CELLARS OF THE EXPERIMENT STATION BUILDING.

The *Cellar*, which is entered by a stairway leading down from the hall of the basement, is built with extra heavy brick walls laid in a mixture of mortar and cement, and, besides, cemented on the outside. The floors are of four-inch concrete, sloping so as to permit the outflow of any water, that may seep in from above or be spilled on the floor, through a drain laid on the outside just above the footing of the walls, and emptying into the creek at its lowest point, the southwest corner of the building. At first there was some difficulty from springs derived from the creek above, but this has been overcome, and the cellars are now as dry as is desirable.

The temperature of each compartment can be regulated independently of the rest, there being heavy doors between. Ventilation can be had either through the transom lights placed in deep brick areas (see sectional view) or, if it be desired to exclude the outside air from that direction, as in winter, the flues in the chimney-stacks can be used for the purpose, with the aid of gas flames, if necessary. All the cellars are provided with wide shelving of heavy, rough pine, upon which the packages containing wine samples can be stored, convenient to access. Rough tables, for the same purpose, supported on trestles, easily shifted according to the requirements, occupy the floor.

THE WORK OF THE EXPERIMENT STATION AT BERKELEY.

As the increase of means afforded by the United States Experiment Station Fund inaugurates a new era in the work of the station, it is proper to give, at this time, a summary of the kind and amount of work done by the Berkeley station since its establishment.

The fact that the experimental work of greatest practical utility must differ in each State or climatic region, and with the greater or less progress of settlement or population, is too obvious to need extended comment and illustration. In the newer States and Territories the question is not how to maintain the fertility of the soil, but rather which soils are most likely to afford the settler a comfortable living, and what cultures are best adapted to the prevailing conditions of soil, climate, and market? Later in time, and with the incoming of a stable population, comes the question of the *maintenance* of profitable production by the cheapest and most effective means; and still later, the more minute discriminations as to the exact composition of fertilizers, feeding stuffs, and their most advantageous use, leads to such work as now chiefly occupies the attention of the stations of Europe, and of the older States in this country. California is still in the

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first and second stages; the questions to be determined are broad and fundamental, and upon the answer frequently depends the weal or woe of whole communities, or even of extended regions.

Physical and Agricultural Features of the State.—In view of the great diversity of soils and climates within the limits of the State of California, it is obviously of the first importance that the experiment station should be in possession of all the data needed to make intelligent recommendations in response to questions and inquiries of all kinds that are addressed to it, especially in regard to the probable value and the adaptation of lands to certain cultures. This necessity having been felt from the very beginning of its work, the original basis of the latter was that of an agricultural survey, made with a view to the collection of data for a complete description of the agricultural features of the State, including the construction of a soil map.

This fundamental work has been kept steadily in view, but the pressing demand for special work, in elucidation of questions of immediate practical importance, has in a large degree overlaid it in consequence of the limited working force and funds at command.

Early in its history (1877) the station issued a bulletin giving directions for the taking of representative soil samples, accompanied by accurate descriptions of the natural features of the region concerned. A very important contribution of such samples was furnished by the liberality of the Southern Pacific Railroad Company, consisting of over four hundred specimens taken, in part with notes, by an engineer, Mr. N. J. Willson, who traveled for that purpose over most of the company's lines within the State in 1880.

The examination and, when desirable, the analysis of samples so furnished (now amounting to over one thousand two hundred), have served as the basis for the classification of the lands of the State. The first results of this work are given in Vol. 6 of the report of the Tenth Census of the United States, as a monograph on "The Physical and Agricultural Features of California." It is intended to continue and amplify this work as rapidly as the financial resources of the institution will permit, and to practically confirm the accuracy of the deductions so obtained, by the establishment of outlying culture experiment stations in the several climatic subdivisions of the State.

Three such stations have already been established and equipped, representing, respectively, the foothills of the Sierra Nevada, the San Joaquin Valley, and the southern Coast Range. The land and buildings for these stations have been obtained by donation and subscription in the regions concerned, showing the public interest in the work. Their running equipment and maintenance are defrayed out of the Congressional appropriation under the Hatch Act, and it is estimated that a fourth station, intended to represent the southern region of the State—Los Angeles, San Bernardino, and San Diego—can be similarly maintained. Most of the expense of home work of the Central Station at Berkeley is now, as has been from the beginning, defrayed either from appropriations made for the purpose by the Legislature, or, as at present, directly from the State University Fund.

In addition to the general culture sub-stations just mentioned, three exclusively *viticultural* stations have been established under private auspices; the use of the land and of grafting stocks, and ordinary cultivation, being furnished by the owners, while other expenses are borne by the Station Fund.

Of course, all these stations taken together do not nearly represent more than half of the climatically different regions of so large a State as Cali-

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fornia, coextensive with the Atlantic coast from Boston to Savannah. To satisfy the requirements of the whole, additional appropriations from some source will be necessary.

Chemical and Physical Investigations.

Among the more important *general results* obtained in the course of this work with regard to the *character of the soils of the State* are the following:

In nearly all cases they are *calcareous, i. e.*, contain enough of carbonate of lime to impart to them the distinctive character of such soils, and to render a farther addition of that substance as a fertilizer superfluous and ineffective.

The great majority contain amounts of *potash* largely in excess of those found in the soils of the region east of the Mississippi; very often exceeding one per cent.

Potash salts are often found circulating in the soil water; the conclusion being that the use of potash as a fertilizer will likewise be uncalled for for a long time to come. On the other hand, it has been found that *phosphoric acid* exists in the soils of California in relatively small supply as compared with those of the East, and of Oregon, Washington, and Montana.

Actual trial both at the Central Station and by farmers has corroborated the conclusions flowing from the above facts, viz.: that while the use of simple phosphate fertilizers has produced marked effects on soils somewhat worn, the application of potash fertilizers, and of lime, has rarely shown any perceptible results. The conclusion that money expended on the purchase of fertilizers of these classes does not return good interest at present is of no mean practical importance.

These investigations have called attention to the broad fact, heretofore overlooked, that *the accumulation of lime in the soil of arid regions* is as necessary a consequence of the climatic conditions as is that of the alkali salts; and that such countries must, under ordinary conditions, be expected to have calcareous soils. This generalization is amply verified by numerous soil analyses from the States and Territories west of the one hundredth meridian, made in connection with the Northern Transcontinental Survey, but thus far unpublished.

Alkali Lands.—The investigation of alkali lands has received much attention and study, with respect to their composition, mode of reclamation, and culture plants adapted to their peculiar conditions.

This subject is of growing importance, not only because of the great intrinsic fertility of the alkali lands, many of which have actually been shown to suffer from a surfeit of valuable plant food, but also because the practice of irrigation without a proper provision for drainage, and in some cases natural conditions in the subsoil under cultivation, cause alkali to rise where none was ever known before. The crude attempts to reclaim alkali lands by surface flooding, heavy manuring, etc., having resulted in failure, their study was undertaken from the earliest days of the station, the nature of the alkali salts determined, and the means for the repression of their injurious effects indicated, first in the report of the station for 1880, the demand for which quickly put it out of print. The portion treating of alkali lands and irrigation waters was then separately reprinted in 1886, and the demand for information on the subject has now nearly exhausted the second edition, copies having been asked for and sent to all the States and Territories west of the one hundredth meridian, and to many applicants east of the same. The remedies suggested in this publication are largely based simply upon the diminution of surface evaporation, the prevention

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of the formation of surface crusts, and, in case of the presence of the most noxious ingredient, carbonate of soda, its neutralization by means of land plaster, which converts it into a harmless neutral salt. The analyses having further shown the presence in most of the alkali salts of large supplies of *potash salts*, *soluble phosphates*, and *nitrates*, the high and lasting productiveness of these lands when reclaimed has been placed beyond all cavil, and has, in numerous cases of intelligent treatment, been amply confirmed by experience.

Waters.—Parallel with the investigation of the soils, the examination and analysis of the waters of the State have been pursued with a view to ascertaining their qualities for irrigation, as well as for domestic, manufacturing, and medicinal use.

As regards waters for domestic and manufacturing use, in numerous cases the unfitness of well and spring waters for these purposes has been shown, and that they had been the cause of disease in man or beast; while in other cases the means have been shown for rendering waters, unfit for use in their raw state, fairly good by appropriate processes.

The analysis of medicinal waters has not been carried out to any great extent, partly on account of its disproportionate laboriousness, partly because such work can usually be paid for by those interested.

It has thus been ascertained that there are important differences in the mineral ingredients of the several irrigation streams; that the water of some is exceptionally pure (*e. g.*, Mokelumne and Kings Rivers), while others contain enough of alkaline salts to render certain precautions in their use desirable or necessary; while still others supply such large amounts of potash as to render it probable that that ingredient will scarcely ever require any other source of supply for current replacement of what is withdrawn by crops. In the case of Tulare Lake, an examination of its waters showed its entire unfitness for irrigation purposes, and prevented the construction of costly irrigation works that would have been worse than useless. The same has occurred in the case of a number of artesian wells yielding highly saline or alkaline waters.

Other interesting facts concerning the waters of California have been presented in the reports for the last twelve years, and latterly in a special report on "Waters and Water Supply" of the State.

Rocks, Marls, etc.—The examination of rocks, marls, gypsum, and other materials connected with agriculture, have also formed an important portion of this work; while, on the other hand, the examination of artificial or commercial fertilizers is but little called for, since as yet these fertilizers are but sparingly used, and so long as no fertilizer control is exercised by the State, the publication of such analyses is inexpedient.

The need of an abundant and cheap supply of land plaster for use on the more or less alkaline lands of the State has caused the transmission to the station of a great number of samples of all kinds, most of which turned out to be limestone in various forms. The indications furnished by analysis have in several cases, however, resulted in the search for and actual finding of gypsum deposits; one of which, in the neighborhood of Bakersfield, in Kern County, promises to relieve speedily the present difficulty of obtaining this important material at a living rate.

It may be mentioned in this connection that in one case it was proposed to erect a mill for the grinding of an impure limestone to be used as a fertilizer; the occasion being favorable reports upon the effects of such dressings in New England. The statement that to apply limestone as a fertilizer in a region where most soils already contain from 3 to 8 per cent of carbonate of lime would be useless and would not be recommended by

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the station, and that natural marls will supply all that is desirable in that direction, promptly caused the abandonment of the enterprise before much money had been invested. While the prevention of unprofitable ventures is not always thankfully received by those concerned, this function of the station is none the less important.

Agricultural Products.—The examination (including analysis, when necessary) of agricultural products of various kinds, such as sorghums, sugar canes, sugar beets, and the by-products of sugar making therefrom; watermelons, oranges, lemons, etc., from different varieties and localities, has been more or less constantly part of the station work, as occasion demanded. Tanning materials and various other vegetable products of technical interest have likewise formed the subject of research. The urgent demand for information on a great variety of problems of direct and immediate practical importance has relegated the investigation of the relative values of feeding stuff of various kinds to a future day, although the peculiar Californian practice of using the cereal grasses for hay almost exclusively, gives room for a great deal of important work.

The investigation of the quality of *sugar beets* has from the first been steadily pursued by the station, since at the very outset the high grade of the roots grown in favorable locations had been ascertained, and it therefore seemed to be merely a question of time when the beet sugar industry would become of great importance to the State. It may fairly be claimed that the persistent investigation and direct proof of the excellence of California-grown sugar beets has had its full share in the conversion of private and public opinion from its first bias toward sugar cane and sorghum. The same line of work will, of course, be continued in the newly established stations.

The station's investigation of the sugar and syrup-making qualities of watermelons, made in 1879, put an end to the proposition to manufacture sugar from this fruit, which is produced in great perfection and profusion in the Great Valley.

It is hoped that the demonstration of the inferiority of dried fruit heavily sulphured according to the prevailing custom, will finally accomplish the abandonment of this objectionable and foolish practice.

Field Cultures.

Collections and Culture Tests of Cereals.—Naturally, in establishing experimental plantations in a State of such vast cereal resources as California, the earliest attention was given to securing a collection of the best varieties of cereal grains from all parts of the world. A foundation for such a collection was made in 1878 by the purchase of a large collection of European and Asiatic varieties from an enthusiastic collector, and the collection has since then been largely increased from year to year by purchase and by donation. This collection at the present time includes, in round numbers, one hundred and thirty varieties of wheat, seven of spelts, thirty-nine of barley, five of rye, thirty of oats, a few buckwheats, etc. It has been made of public service in several ways. The growing plots have been carefully labeled and have been studied with interest by many visitors to the grounds. Large collections, including in some cases as many as two hundred varieties, have been displayed in specimen heads or sheaves and bottled grains at the Fairs of the State and of the Mechanics' Institute; the varieties have been carefully studied from year to year with reference to their adaptation to local climatic conditions, their resistance to rust and to the attacks of the Hessian fly, and varieties possessing especial claim to attention have

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been widely distributed among the grain growers of the State. It is doubtful whether any State institution in the country has so full a collection of this kind as that possessed by this station.

Grasses and Other Forage Plants.—The introduction and testing of forage plants naturally forms a part of the introduction and distribution of plants, to which allusion has been made, but special reference is made to it because of its importance and the great popularity it has gained. No greater public service can be rendered than the designation of grasses and forage plants adapted to the divers conditions in soil and climate of the different areas in California. Naturally there is during the rainy season, in most parts of the State, a luxuriant growth of annual plants, which give rich pastures for a short period; but these plants quickly run out by close pasturing, which interferes with their seeding. For years there has been a constant call for perennial plants which will retain their verdure during the dry summer, and being "root" plants, and not "seed" plants, as the popular saying is, will survive much closer pasturing than annuals. Alfalfa (*Medicago sativa*) has proved a priceless boon upon the naturally moist or irrigated lands of the interior and southern coast valleys; but alfalfa does not make winter growth, nor does the plant thrive on the uplands, which constitute the great part of the pasture lands of the dairy regions of the Coast Range. For these reasons alfalfa does not meet all requirements, and it has been the effort of this station, and its coöperating experimenters in different parts of the State, for ten years past, to discover plants of character and growth to meet the special demands. The reports of the station show that great progress is being made in this direction. Especially full data are given of the results of wide trials of Schrader's brome grass and Hungarian brome grass (*Bromus unioloides* and *inermis*); New Zealand millet grass (*Milium multiflorum*); "gazon" (*Paspalum dilatatum*); Texas blue grass (*Poa arachnifera*); tall oat grass (*Avena elatior*); orchard grass (*Dactelis glomerata*); perennial ray grass (*Lolium perenne*); and with a new Japanese grass (*Agropyrum Japonicum*, Vasey). All of these exhibit features of value, and are coming into wide use. Experiments with the growth of sorghum varieties, especially of "Amber" and "Orange" canes, and of "Kaffir" and "Egyptian" corns, and of "Jersey kale," have demonstrated the possibility of securing with them on moist or irrigated land a vast amount of summer feed, which is of inestimable value to dairymen in keeping up the flow of milk in the summer time, when the natural pastures afford only "dry feed," which, though very rich, leads to rapid "shrinkage" in the milk flow. Just now the introduction of the Silo system of fodder preservation is gaining some prominence in this State, the purpose being to preserve winter and spring growth for *summer* and *fall* use—a complete reversal of eastern dairy economy. In this investigation of fitness the station will continue to participate.

Culture Tests of Fertilizers.—The question of how to render the refractory soil of the greater part of the experimental grounds, the "hill adobe" (see above, the description of the soils of the Central Station), more tractable and productive, was early approached by means of culture tests of fertilizers. As shown in the reports for 1879, 1880, and 1882, a number of plots of one twentieth acre each was set aside for this purpose and sown to cereals (oats or wheat) for four consecutive years. The fertilizers tried were potash salts, ammonia salts, sodic nitrate, phosphates, gypsum, and lime. Summarizing the results of these experiments, it may be broadly said that only the phosphates and nitrogenous manures and lime produced any consistent and sensible effect upon production.

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As these results agreed with the forecast made in 1877, as the result of the analysis of the soil in question, it was deemed unnecessary to proceed farther with these tests, and none have been made since, save to ascertain the maximum dose of phosphate that would be useful. This was found in a dressing of eight hundred pounds of bone meal per acre. Superphosphates not being then in the market, no tests were made with them.

Horticulture and Viticulture.

Fruit Culture.—In this department of horticulture two chief branches have been kept in view, viz.: to introduce and propagate for distribution fruit varieties and other plants of economic value, from the various temperate and sub-tropical countries of the world; and to aid in the identification or correct naming of fruit varieties, by the maintenance of a standard collection, and by the determination of samples sent in for the purpose by producers. This is of particular importance in respect to grapes.

Of the land devoted to orchard experiments much is naturally ill suited for the growth of fruit trees, but has been recently greatly improved by underdraining, manuring, and thorough cultivation. The shaping of the oldest trees, when first planted, with high heads and too many main branches, is chargeable to an earlier administration, which allowed an English gardener, without much California experience, to train the trees in a way which would have long ago cost them their lives if the planting had been done in a hot interior region of the State. The later plantings have been given the low heads and modified goblet form which experience has shown to be best suited to California conditions—even if such form cannot be successfully claimed to be the best for fruit trees in any region where it is not necessary to guard against breaking down from the thawing of very heavy snowfall.

The advantage of underdraining orchards on relative subsoils has been clearly demonstrated by experience with the station orchard during the last two years. Portions of the area upon which cherry trees had been killed by standing water, and upon which it was impossible to go with a team during the wet season, have been rendered much more suitable for tree growth, and capable of cultivation at the same time that work is done upon other portions of the orchard naturally well drained. The general facts of this underdrainage work have already been given. Of the orchard drains, it may be added that mains were laid in the natural valleys, and laterals were carried therefrom between each alternate pair of tree rows. By this mode the laterals were about fifty feet distant from each other. In such heavy retentive soil it would have been better to place the laterals somewhat nearer to each other, but the location of the trees prevented. As the ground is, however, quite sloping, the long distance between laterals is of far less importance than if the surface were more nearly level. It has been shown that the subterranean water passes quite readily down the slope and finds its way into the tile. Soon after heavy rainfalls the mains discharge their full capacity, and considering the speed of the outflow, because of the great inclination of the pipes, the volume of surplus water taken from the soil is immense. Any one contemplating drainage of soggy hillsides may obtain points of interest by a personal visit to the drained lands of the station, and by information gained from explanation of the matter by the foreman in charge.

Of the public uses thus far served by the station orchards it has been frequently noted that the growth of the trees and the character of the fruit of the several hundred correctly named varieties now in bearing are studied

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with much interest by amateur and professional horticulturists who visit the station for that purpose. Large collections have also been shown for several years at the State Fair and at other industrial exhibitions, and have attracted much attention. It is true, that owing to the prevalence of coast fogs and the influence of unfavorable soil, the pears and apples from the station orchards have not compared well in size and beauty with fruit grown in more favorable locations; but the advantage of large collections correctly named is generally recognized. When fruit specimens of the same variety from the several outlying stations can be exhibited side by side, as it is hoped to do in the future, valuable comparative data will be afforded.

Another way in which the standard collections of the station are aiding in the correction of confused local nomenclature is seen in the constant demand which exists for scions true to name, the products of which become standards for comparison in the different neighborhoods to which they have been taken; and thus the local modifications of fruits by changes of soil and climates are ruled out in making comparisons, or noted for contrast, when such studies seem desirable.

Very little has been done with small fruits at the Central Station, because of the unfitness of available soil to their growth, and because the insufficiency of the water supply would render any attempt at the amelioration of the soil for these cultures useless. Adequate and continued moisture of the surface soil during the summer season is essential for success with most of the small fruits in California.

Viticulture and Wine-Making.—Of special cultures needing close and extensive investigation, viticulture and wine-making are most prominent. Between three hundred and four hundred varieties of grapes have been introduced into the State, and planted quite indiscriminately, with little regard to climatic adaptation. Moreover, the processes of wine-making most appropriate to the special conditions of the climate and the grapes produced under its influence, are but very little understood, the members of each nationality being inclined to adhere to the practice of their own country, and thus producing, from the same materials, wines of the most diverse kinds and values. This miscellaneous and hap-hazard practice has tended to the production of a large bulk of unclassifiable and ill-made wines, the throwing of which upon the market has cast unmerited discredit upon California wines as such.

So soon as its means permitted, the station began the investigation of the character of the grapes produced in the various portions of the State where the industry has taken hold, in order to determine, by analysis as well as by experimental wine-making, the peculiarities impressed upon each grape variety in each climatic region. At first it was attempted to reach the information desired by the analysis of wines obtained from the several regions; but it was soon found that this was misleading, on account of the varied and indefinite modes of wine-making, and that the wine of each variety would have to be made in the laboratory itself in order to gain definite knowledge of its chemical peculiarities at least. Inevitably this had to be done on a small scale, since otherwise the numerous varieties and localities could not be even approximately covered within a lifetime. While the wines thus produced would not correspond accurately to those made on the large scale, yet they would convey an approximate idea of their peculiarities and quality, and in small packages would mature very quickly.

Another difficulty was then encountered in the confused nomenclature of the grapes sent, that could not be rectified from the fruit alone. Thus,

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under the name of "Burgundy" or "Pinot," fully eight different varieties came to hand.

It was thus obvious that the establishment of viticultural culture stations in the several climatic regions of the State could alone be relied on to supply authentic material and to rectify the confusion of names.

The financial means for doing this were not at command before the passage of the Hatch Act; but by the liberality of private individuals, owners of large vineyards, three vine-culture stations were established under an arrangement by which the owners undertook to allow the use of a sufficient number of stocks for grafting the varieties of chief interest for the locality, and to do the ordinary work of cultivation without expense to the institution.

Besides these three special viticultural stations, each of the three general culture stations, of course, has its vine plantation. There is also a small collection of vines growing at the Berkeley station, but as grapes do not usually mature there, this vineyard has chiefly subserved the purpose of experiments in grafting, and the rooting of cuttings of different resistant varieties, and to compare their relative immunity from attack; for the study of the habits of the phylloxera (which unfortunately was introduced at the time of planting), and especially to test the various modes of repressing its ravages. In the absence of reasonable facilities for doing this work in the infested districts themselves, this plot of about eighty vines has been maintained until now; but in consequence of permission obtained from the governing Board, to use for this purpose a plot of infested vines set apart at the State Home for Feeble-Minded Children, in Sonoma Valley, the vine plot at the University will be eradicated this year (1890). It is a curious fact that the phylloxera has not found its way from this plot to any of the other vine plantations on the grounds, either above or below the wind, the development of the winged insect having been very rare.

From the special viticultural stations valuable data concerning the bearing, time of maturity, and liability to injury of the several varieties under the local climatic conditions, best mode of pruning, etc., have already been obtained; some varieties have proved utterly worthless as bearers in their locality; others highly valuable from the same point of view. A number of varieties grown under different names have been proved to be identical, and others grown under the same name to be entirely distinct. Newly imported varieties have been propagated for trial and distribution, as the Huasco Muscat grape, of Chili, which is now grown in several localities in preference to the Alexandria Muscat. A vast amount of important work in these several directions remains to be done, when the vines at the several stations shall be older.

For the purpose of pursuing the investigation of the grape samples obtained from the stations or from private vineyards, a small laboratory and cellar were early established at Berkeley, by the aid of a legislative appropriation, and these were gradually enlarged, until now the entire basement and three cellar rooms beneath the station building are occupied by this work, besides the laboratory room and office above. Four reports on the viticultural work have been issued, dated, respectively, 1881–2, 1883–4, 1885–6, and a partial one, 1888; the last three separately from the general report, on account of their large volume and special nature. The results contained in these reports, and those now in progress of elaboration for the report of work, 1887–9, cannot readily be summarized, being largely a mass of detail pertaining to each grape variety, including twelve hundred and one analyses of musts and four hundred and fifty of wines, believed to

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be the largest connected series of the kind on record. The following points may be noted:

In appropriate soils and climates, the numerous varieties of the European grape show their distinctive qualities and differences, in California as well as in Europe. The station has studied the differences produced in the same grape variety by difference of climate, with certain well marked results, such as the following: Some grapes that in the bay climate of California produce highly colored wines, will, in the dry and hot climate of the San Joaquin Valley, lose that quality to such extent that dry red wines cannot be made from them; and they will in general show a marked increase in tannin contents, and a decrease in acid. The resulting dry wine will therefore be light colored, astringent, and flattish, resembling no wine of commerce and adapted to no existing taste. The Carignane grape is one example in point. Still others (*e. g.*, Gamay) will retain a deep tint, but with lack of acid and increase of tannin will yield an unclassifiable wine of no merit, useful only for certain blends. The presence of alkali in the soil appears to aggravate these changes in a marked degree. On the other hand it has been shown that, contrary to expectation, the foothills of the Sierra Nevada will *not* yield lighter wines than the valley, even at two thousand feet elevation; the grapes become equally as sweet, but have somewhat more color, ferment better than the valley grapes, and their wine has better keeping qualities. Both regions are manifestly best —and excellently well—adapted to the growing of sherry, port, and raisin grapes, while the slopes and valleys of the Coast Range must be looked to for wines of the claret, Burgundy, Sauterne, and Rhenish types. That ultimately valuable peculiar types, resembling those of southern France, northern Italy, Austria, and Hungary, will be established, and appreciated as such by the world, there can be no doubt.

Several series of elaborate experiments on the best methods of *fermenting* wines in the climate of California have been made at the station, and the results published. It has been shown that the prevailing practice of hot fermentations is responsible for a large proportion of defective fermentations and wines; and the means for preventing undue rise of temperature, of favoring a sound fermentation, and reviving the same when checked, have been set forth both by experiments and precept. The subject of wine colors, their progressive extraction from the grape skins during fermentation, the time of maximum color for each, and the subsequent rate of decrease in the wine, has been studied in detail, and important precepts for practice deduced therefrom, the subject being one that has heretofore received no systematic study even in Europe. It has thus been conclusively shown that the common impression that long maceration of the wine on the pomace increases the color is erroneous; that practically nothing is gained in color after the fourth day from crushing, and that for a number of reasons an early drawing-off of the young wine is to be recommended in California.

The subject of wine-heating, or "pasteurizing," has been experimentally studied for some years, and the advantages as well as the weaknesses of the process have been investigated, the difficulty of keeping wines grown in the hotter portions of the State without fortification being very great.

The new electro-magnetic process of wine treatment has been studied, so far as the resources of the station (which do *not* include a dynamo and power) would permit; and the unexpected effects upon the chemical composition of the wine have been demonstrated. It has also been shown that the wine is completely *sterilized* by proper treatment, and exhibits surprising keeping qualities thereafter, far exceeding those of "pasteurized" wines. It is the opinion of the Director that this process is destined to play an

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exceedingly important part in the wine industry of California in the near future, if carefully adapted to the several kinds of wine, and not made unavailable by the exactions of the patentees.

The lees of a number of varieties made into wine at the station have been determined as to amount and character, and their contents of tartrates of potash and lime determined, with a view to the manufacture of cream of tartar.

A large number of wine samples have been sent in for examination, whether as to general quality, or the ascertainment of the cause of certain faults and of the best remedy, or finally, for the detection of adulterations. The latter subject has occasionally occupied much time, especially as regards the alleged coloring of wines, and the use of salicylic acid and other antiseptics, for preservation. To the honor of the California product it should be said that in but a few instances such additions have been detected, and these mostly coming from one and the same commercial source.

The study of *vine diseases* has at various times occupied much time. The field work by which the distribution of the phylloxera within the State was ascertained was carried out conjointly with the State Viticultural Commission, and recorded in the report for 1882. Subsequently the diseases of vines in the southern part of the State have formed the subject of study, and the mysterious disease that to-day baffles the observers detailed by the Department of Agriculture and the State Viticultural Commission was first investigated by Assistant Morse in 1886, when, apparently, it either originated or first took a serious scope. It was then attributed by him to the extraordinary meteorological conditions which prevailed in February of that year, when thousands, not only of vines but of fruit trees, died, all over the State, apparently from the same cause. It was therefore supposed that the trouble would disappear when the damage of that season should have been done away with. This expectation has unfortunately not been realized; but the question has not been greatly advanced toward its solution since.

Other special investigations in the field have many times been made in response to requests from individuals or communities.

Elaborate investigations were made on the proposed use of finely divided quicksilver as a remedy against the phylloxera. It was found that the presence of a small proportion of mercury in the soil would effectually prevent the insect from passing through it alive, and that it might thus be used as a preventive of invasion by placing the mercurialized earth around the stocks. But the diffusion of the vapor through the soil is too slow to reach outlying roots within reasonable limits of time, and thus the method cannot serve as a remedy where the insect already exists in the soil.

Many other alleged remedies have been tried as they came up, but none of special merit have been noted. One—the infusion of insecticides into the sap—is still on trial.

The examination of specimens of diseased vines sent in for the determination of the disease and possible remedies, has been a steady and prolific source of labor.

The station is equipped with the standard European literature and portraiture of the *Vinifera* varieties, and possesses a very comprehensive collection of California-grown vine cane and leaf, supplemented with seed collections of the same. These materials are in constant use, and have already served for the correction of the confused local nomenclature in many instances.

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Forestry.

In accordance with the general plan of culture experimentation, a part of the station's work has been to plant and maintain plantations of forest trees, and to note carefully the growth and character of all obtainable species thereof; to determine their adaptations to different conditions of the soil, rainfall, and temperature, to the end that lists can be prepared which can be commended to tree planters in different regions of the State.

Fairly large plantations of forest trees have been made, and a considerable number of species have been introduced and studied. The lack of hardwood timber suitable for the manufacture of agricultural implements, staves, etc., in California, early led to the trial of the Eastern oaks, hickories, and other species valued as timber trees. These experiments have progressed sufficiently to show, with the data casually obtained from private parties, that the growth of the oaks and hickories is very slow and unsatisfactory, and that their introduction for large-scale timber culture is not to be encouraged. On the other hand, we have elicited the somewhat unexpected fact that the European or "English" oak (*Quercus pedunculata*) makes a very rapid and satisfactory growth, even under conditions of extreme drought, provided the soil be deep, so as to enable it to send its tap root down to moisture. It thus seems probable that this oak will be the preferred hardwood tree of the future for the Pacific Coast; and the station has for years past distributed both acorns and young seedlings to parties in various portions of the State, and all reports thus far agree as to the satisfactory adaptation of the species. It will, of course, require some time to ascertain definitely the quality of the wood produced; but the fact that the growing season is nearly twice as long in California as in its native countries, would seem to make it probable that the wood has ample time to harden.

Of other European trees the cork oak has been somewhat extensively distributed, and does well, promising to supply in the future a most essential need for the wine industry. As a shade tree the cork elm (*Ulmus suberosa*) does remarkably well.

The black wattle (*Acacia decurrens*), so valuable both as a rapid producer of tanbark and firewood, has been extensively distributed by the station, with very satisfactory results, from Colusa to San Diego County. Of other acacias the *A. melanoxylon*, or blackwood acacia, has been distributed to a limited extent in the coast counties, where it does exceedingly well, demanding, however, a slightly milder winter climate and better soil than the black wattle. Unlike other acacias, it forms a straight pyramidal tree, resisting winds well, and reaching large size, say sixty feet or more.

A large number of species of *Eucalyptus* is represented on the grounds of the station and University. Of these the *E. globulus*, or blue gum, is thus far the most successful here as elsewhere in the Coast Range south of the bay, although its merits as a timber tree are not as yet suffieiently appreciated. The red gum (*E. viminalis*) is next in general adaptation. Of other species of eucalyptus the noted Jarrah (or Yarrah—*E. marginatus*) of western Australia has been tried on the station grounds for a number of years, and also distributed to a limited extent. It has thus been placed beyond doubt that large areas, especially in Southern California near the coast, would be well suited to the growth of this tree, so valuable for its resistance to the teredo. As a general thing it can be said that Australian trees are better adapted to the State, especially to the coast section, than any other class of exotic timber trees thus far tried.

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Next in importance to the Australian trees come perhaps the natives of the Mediterranean region, *i. e.*, those from south Europe and western Asia. The *Spanish chestnut* is here a more rapid grower than the American variety, and the same is true of the *Oriental sycamore*, as compared with the eastern American. From the latter climate, nevertheless, the box elder and black walnut have been measurably successful—the latter particularly on the black prairie (adobe) soils of the Coast Range. From the south, the pecan and tulip tree do fairly well.

From the humid climate of Japan, the so called Japanese elm (*Planera cuspidata*) succeeds well on the coast, but, like other Japanese deciduous trees, suffers somewhat from our hot and drying north winds.

Of evergreens the *camphor tree* of Japan and China is evidently valuable. The growth of trees distributed from the station proves its adaptation to a large area. It seems to be specially adapted to the redwood region of the coast; but in Yuba County, in the Great Valley, one tree has reached the height of fifty feet in fourteen years. Its exemption from insect pests alone recommends it for general planting, both as a timber and ornamental tree. Several ounces of camphor were made at the station laboratory in 1885, from the leaves of locally grown trees.

So far none of the *Chilian* trees tried have proved much of an acquisition, their growth being quite slow, although the so called "pepper tree" (*Schinus molle*), from Peru, grows rapidly in dry soil, and in Southern California has attained large dimensions. In spite of repeated trials with seed of the *Quillaya saponaria*, or Spanish-bark tree, we have never succeeded in producing a single plant, no doubt because the small seed suffered in transit.

Few species of trees seem as well adapted to the climate, and to resist so well the drying winds, as the various species of *Morus* that have been tried here. Especially can this be said of the *Morus Japonica*, a species equally valuable as food for the silkworm as for shade. It far excels the *Catalpa speciosa*, which suffers from dry winds. The mulberries at all the stations have grown exceedingly well; at Paso Robles, without irrigation, showing no sign of suffering from drought, while at Tulare, with irrigation, the growth has been very rapid. Mulberry cuttings of all varieties have been called for and distributed for a number of years, to all parts of the State.

There can now be no question that with the English oak, the two acacias mentioned above, the camphor tree, and the several eucalypti (all rapid-growing trees), the entire Coast Range of California, so far as it has sufficient soil, can be covered with forest if desired; and the same applies to the Great Valley. Of trees of slower growth there are, of course, very many that could be used.

Inter-Tropical Plants.—As heretofore stated, the regular meteorological observations at the Central Station at Berkeley are now being made by the Department of Civil Engineering and Astronomy of the University; those at the outlying stations by the foremen in charge. The discussion of these observations, from whatever source or locality, in connection with the possible success of untried culture plants, forms an important section of the station's work. As a result of such discussions, supplemented by actual culture experiments, the proposed planting of coffee, cinchona, the chocolate tree, and other tropical fruits within the State, has been abandoned as hopeless, while the success of others, predicable upon similarity of climate to old world countries, has been predicted and proved. Several cinchona trees had been brought nearly to the point of blooming in the comparatively moist and equable climate of Berkeley, and it was hoped

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that seeds from these trees might prove the progenitors of hardy plants; but the extreme cold of two years ago killed them to the ground, and despite great care they could not be saved. Elsewhere their leaves suffered so much from the extreme dryness of the air as to render success hopeless.

Insect Pests and Diseases of Plants and Animals.

The entomological work of the station began in 1875 with investigation into the occurrence of the grape phylloxera in California, and this special branch of entomological inquiry has been constantly in hand. At first, as shown by the earlier reports, the definite determination of the area infested, and the somewhat modified life history of the insect in this State, to which is due its comparatively slow progress, were the leading subjects of investigation.

It has thus been shown that the insect hibernates in California in its ordinary larval form as well as in that of eggs; that there are seasons in which the winged form is abundant, and others in which few or none appear; the former being usually the case in years having summer rains. Numerous remedies suggested have been tried and found wanting; and the conditions under which the use of "deadened" mercury can be used as a preventive of attack have been studied. In this connection the rapidity of the diffusion of mercurial vapor in soils is still being tested.

For the last ten years or more the introduction and distribution of stocks resistant to the phylloxera, the various methods of grafting the *Vinifera* varieties on these stocks, and other related matters, have received attention. The publications of the station on these subjects have been in constant demand by vine planters; and the results therein foreshadowed have been realized in the success of resistant vines in infested regions.

In the warfare against *scale insects*, which became a serious menace to California orchard interests about the year 1880, the station has maintained a leading part. Members of its staff have participated in fruit growers' conventions, called to urge united work against the pests by the enactment of repressive laws and by the prescription of effective insecticides. The laboratory of the station has also been engaged in the analysis of commercial alkalies and soaps offered for insecticidal purposes, warning the public against adulterated goods (Bulletin 52), and indicating proper combinations of effective substances, and in the case of whale-oil soap, furnishing a formula, which has been accepted as a standard by the leading local manufacturers (Bulletin 56). More recently the field experiments by a member of the station staff in rendering the use of insecticide gases, and especially of hydrocyanic gas, and in rendering it innocuous to foliage, and in devising a practical method of its application to citrus trees (Bulletins 71, 73, and 79), have proved the basis for several important insecticidal undertakings, and have attracted wide attention.

By experiments covering a series of years on the station grounds, the resistance of a number of varieties of wheat to the Hessian fly has been determined, thus placing in the hands of growers in infested regions of this State varieties which, besides their fly-proof character, prove measurably drought-resisting and productive in a higher degree than many of the commonly grown varieties.

By experiments in the Standard Orchard of the station with various treatments for the codlin moth, the efficacy in California of the Paris green and London purple sprays was demonstrated, and since the publication of the results attained (Bulletin 75), the use of these insecticides against the apple worm has been widely adopted in this State. An elaborate experi-

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ment was also made with the band treatment for the codlin moth, which, as published in Bulletin 75, was mentioned by the United States Entomologist, in his report for 1887, as "the only attempt with which we are familiar to ascertain and tabulate the exact proportion between the worms on a tree and those caught by the bands."

Experiments with gas lime as an effective application for the woolly aphis on the roots of apple trees, resulted in the recommendation of a careful and sparing application (Bulletin 55)—a prescription which has been widely used where gas lime is available.

Fungous Diseases of Plants.—The work of the station in this line has been chiefly directed to the prescription and application of effective fungicides. Extended observation and experimentation has been had with the oidium of the vine, and the proper use of sulphur therefor; also with the occurrence of the *Fusicladium dendriticum* on the apple and pear. For the repression of the latter a prescription by the station of a sulphide of soda and whale-oil soap, used as a spray, has been found widely effective in districts liable to the disease. The French copper-lime remedy for the downy mildew was first republished in this country by the station (Bulletin 51, Jan. 15, 1886), and its efficacy against the powdery mildew, the peach curl-leaf, and *Fusicladium* immediately tested, with practically negative results.

Diseases of Domestic Animals.—Attention to this branch of investigation has always been in contemplation, and a number of special reports on cases submitted for examination have been made. But the consumption of time and funds by other lines of work, for which there seemed a louder public demand, has prevented a realization of the intention. It is hoped that the station may be soon furnished with a competent veterinarian, with equipment adequate for original investigation and for supplying the popular demand for information and advice. A bill looking toward that end was introduced at the last session of the Legislature and received some support because of the outcropping of certain animal diseases, which threatened also the human species; but this support was not sufficient to secure enactment.

Distribution of Seeds and Plants.—Under the exceptional climatic conditions prevailing at Berkeley, and in view of the great diversity of climates in the State, it was obvious that cultural tests made at numerous points could alone determine the possible value of new culture plants. In the absence of regional culture stations, the aid of intelligent and interested persons was at first called in individually. The advantages of this plan soon became so apparent that distribution by formal announcement was undertaken, the first notice thereof being given in the report for 1880. This feature of the station work has constantly extended until, during the distribution for 1889, packages containing several kinds of seeds or plants, or both, were sent to nine hundred and ninety-four individual applicants, residing in all of the counties of the State save two of the small mountain counties. The station has adhered from the first to the plan of requiring the applicants to pay a small sum for the packing and transmission of the material they desire. The receipts from this requirement do not fully cover the cost to the station of the distribution; but the requirement is notably good, because it apparently limits the applications to those actually desiring to give the plants a fair trial and to report results, and relieves the station from useless dealings with those who are disposed to apply for anything which can be had gratuitously, without serious contemplation of making any good use of the material secured.

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As a rule, no plants or seeds handled regularly by the trade have been included in the distribution, and so soon as any that had formed the subject of distribution came into that category it was dropped from the list.

Seed Tests.—This is another branch of work which has as yet hardly passed a beginning. Seed tests have been conducted for the guidance furnished thereby in our own field and garden work, and wider investigations have been made by student assistants, of commercial seeds as sold in the San Francisco market. The growing importance of California as a seed-producing State suggests the propriety of extending and systematizing this effort in the future.

A considerable collection of seeds has been already accumulated, among them a number of those of native plants that appear in the several climatic regions of the State as more or less troublesome weeds. The recognition of these could not, of course, be derived from any of the published works on the subject; and it is intended to supply this need as rapidly as possible by the aid of photography. Among the economically important facts observed in this connection is the occurrence of the seed of the yellow melilot (*M. officinalis*) in the wheats of certain regions, with the result that the flour made therefrom obstinately retains a "gingerbread" flavor objectionable to consumers. Hence, such wheat is rejected by millers; but at times the seed of alfalfa or luzerne is mistaken for that of the melilot, and the grain unjustly graded low for milling purposes. It is, therefore, of some importance that the differences between the two seeds should be well understood.

Economic and General Botany.—The *botanical* department is constantly receiving specimens of native and foreign plants for identification and advice as to their possible uses, involving extended correspondence and in some cases not a little laborious research, since the position of California, and particularly of San Francisco, as the center of the trans-Pacific, and much of the Mexican and South American trade, brings contributions from many of the less known floras to its shore. Many very interesting matters are thus brought to the doors of the station and engage its attention in proportion to their possible usefulness in the future.

During the year 1889, two hundred and seventy-nine letters were written by Professor Greene in response to inquiries coming within his province.

Correspondence.—A very large and exacting portion of the station's work is an extended correspondence in the domain of all the subjects mentioned or more or less remotely connected with them, or at times with almost every branch of technical science. While this correspondence involves a heavy expenditure of time on the part of the Director and chief assistants, from the well known disproportion between the facility of asking and of answering questions, yet the amount of information thus received and distributed, and the public interest excited, makes it worth while, for the present at least, to indulge to a reasonable extent the impression of the public that the station is a bureau of universal information and reference. With the progressive increase of the station's printed records the answering of many letters becomes merely a matter of clerical work in mailing documents; yet so varied is the material that is presented from the wide limits of the State, that as the remoter districts are settled new questions are constantly mooted and require attention and discussion. It is estimated that during the past season, aside from the merely perfunctory correspondence involved in the distribution of seeds and plants and the mailing of documents, about one thousand six hundred and ninety letters have been written in answer to questions requiring a more or less elaborate discussion. Many of these letters are subsequently published in the local newspapers, and thus serve

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for the information of the public at large. It is thought that the time and trouble bestowed upon this branch of the work has been largely instrumental in creating a wider appreciation of and interest in the work of the station.

Publications of the Station.—The publications of the station have been of a twofold character, viz.: "bulletins," intended to convey to the public information of immediate practical or scientific value in a condensed and popular form, suitable for publication in the newspapers; and annual (or formerly biennial) reports, embracing all matter previously published in bulletin form, but more in detail; and also other work that may have been done, or discussions that may have become necessary, in the interval since the publication of the previous report.

This plan of publication in a twofold form was formerly followed by the New York Station and by several others, but of late appears to have been abandoned in favor of the issuance, under the name of bulletins, of final reports of work, not to be reprinted in the annual reports. This station having had a prolonged experience of the benefits arising from the plan originally adopted, does not feel justified in making a change therein; since the wider acquaintance with its work resulting from newspaper circulation of the results is thought to offset amply the additional expense of printing.

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THE FOOTHILL STATION.

Location: Five miles north-northeast from Jackson, Amador County.

General Features of the Foothill Region.—The Sierra Nevada falls off steeply on the east, toward the plateau region of the great interior basin; but descends with a gentle slope toward California, on the west. The "foothill" country forms the base of this slope, constituting a belt ranging in width from five to as much as thirty-five miles, east and west, on the eastern border of the Great Valley of California. The face of this country is, of course, more or less hilly, with narrow valleys; but not usually "broken," except in the southern and narrower portions, where agriculture is largely confined to the valleys and lower slopes. In the wider portions of the belt we often find broad-backed, plateau-like ridges extending considerable distances and forming large bodies of agricultural land, even at elevations ranging from two thousand five hundred to three thousand five hundred feet. But the main belt of cultivable lands lies below two thousand five hundred feet, while the "upper foothills," from the latter altitude up to about four thousand feet, are largely rocky and broken, and are chiefly occupied by the lumbering and mining industries.

The climate of the foothill region may be roughly said to be similar, as to temperature, to that of the adjacent portion of the Great Valley, up to about one thousand five hundred feet in its northern and up to two thousand, and even more, in its southern parts. Here, as in the valley, snow lies in winter only for a few hours, or days, if it falls at all, and the fig and citrus fruits flourish; while, within the next thousand of feet above, snow may sometimes lie for weeks at a time (hence "snow belt of the foothills"), and the culture of citrus and other subtropical fruits is precarious. In both belts, however, deciduous fruits succeed finely, and are noted for their fine flavor and good shipping qualities. The summers are warm, the temperature very commonly rising into the nineties in the daytime; but owing to the dryness of the air, this temperature is not oppressive, the more as the nights are always cool.

The following table shows meteorological data for points on the Central Pacific Railroad where observations have been made for a number of years, and partial data for some other points:

Table showing the Rainfall and Average and Extreme Temperature for Summer and Winter in the Sierra Foothills of Central California. From observations of fifteen years, from 1871 to 1885, on the Central Pacific Railroad stations.

Location.	Elevation—Feet	Rainfall—Inches.		Winter Average Temperature.		Winter Extreme Temperature.		Summer Average Temperature.		Summer Extreme Temperature.	
		Total for Season.	Increase, Ft. for 1 inch.	Max.	Min.	Min.	Mean.	Max.	Min.	Max.	Mean.
Rocklin	249	19.1	83.1	66.9	28 3	20.0	46.9	104.1	59.2	114.0	78.2
Auburn	1,360	32.7	87.6	66.7	28.6	18.0	46.1	97.7	55.2	106.0	74.2
Colfax	2,422	44.8		67.7	30.1	16.0	46.2	98.4	56.1	106.0	66.8
Smartsville .	800	33.2	77.0	.....	.....	.....	.....	.....	.....	.....	.....
Nevada City	2,500	56.9		.....	.....	.....	.....	.....	.....	.....	.....

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This table shows remarkably slight differences in regard to temperature to the altitude of over two thousand four hundred feet, the climate of Rocklin being practically the same as that of the adjacent valley. There is, however, a very important difference in respect to rainfall, which, it is seen, increases at a rate ranging usually between eighty and ninety feet for an increase of one inch in the annual precipitation. The data given in regard to Smartsville and Nevada City show a somewhat more rapid increase of rainfall in that section of the foothills as we ascend, implying a more liberal supply of moisture than is found on the ridge traversed by the Central Pacific Railroad.

The increase of rainfall as we ascend is, of course, a modifying factor, as are also the variations caused by alternation of hill and valley, and diversity of exposure; all of which give rise to innumerable modifications of local climate that must be taken into account in determining the adaptation of localities to certain cultures. Thus, it is not uncommon to find in deeper valleys, protected against the western winds, flecks of snow and a wintry chill, with dormant vegetation, while a thousand feet higher up the foliage is fast developing.

The region is well *watered*, being crossed by the main drainage of the Sierra Nevada; and in the forested portions numerous springs and spring creeks are found, with excellent water. These, however, are usually not of sufficient volume, in summer, for irrigation purposes; and while the cereals and many fruits can be grown without artificial watering on the deeper soils, yet the command of irrigation water is very desirable, not only to open a wider range of production, but to increase its quantity and (when judiciously managed) the quality also. Hence the capital importance of the numerous ditches (mostly originally constructed for mining purposes) that take their water high up in the mountains and therefore are capable of watering the highest hilltops in the "lower foothills."

The *soils* of the foothill region are substantially of three kinds, corresponding to the chief rocks of the Sierra, viz.: those derived from granite proper, those formed from the slate "bedrock," and that resulting from the disintegration of the "blue trap" or "bastard rock" of the miners, which is most generally of diabasic type. The eruptive rocks—mostly volcanic tufas—do not usually form important soil areas by themselves, although, of course, contributing to the soils of the slopes and valleys to a greater or less extent, where they form considerable masses. The three rocks first mentioned, and their several modifications, generally alternate in belts more or less parallel to the general trend of the mountains; that is, from south-southeast to north-northwest.

Of the three soils mentioned the granite soil, while fairly productive, is the lightest and least durable; the trap soil is the most substantial, producing good grain crops, but is often quite shallow and stony, or full of cobbles, and correspondingly difficult of cultivation. The slate soil, while not as heavy or substantial, on the average, as the trap soil, but like it of a deep orange-red tint ("red foothill soil"), is the one most generally approved, especially for fruit culture; largely because even when it is shallow, cultivation soon deepens it by the disintegration of the bedrock, into which, since it stands steeply on edge, the roots of trees and vines readily penetrate, obtaining both moisture and mineral plant food.

It is a marked peculiarity of this typical red earth of the placer mines, that it will assume the functions of a soil at once, even when taken from depths of seven to twelve feet. Hence it is that the lands worked over by the early miners, where they have not been subsequently overrun by gravel,

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or denuded of their red soil, soon become covered with the natural vegetation of the region.

Between these three types of soil there lie, of course, many transitions and intermixtures, which are frequently preferred to the typical soils themselves. As in all hilly countries, there are in the foothills stony tracts, in which the bedrock is either actually at or near the surface, or its fragments very abundantly intermixed with the soil and subsoil. In such lands the timber (oaks and pine) is either stunted or absent, and the same is true of the several kinds of "chaparral." Large, sturdy trees always indicate a considerable depth of soil sufficient for all agricultural purposes.

The entire region is more or less heavily *timbered* with several species of oak and pine; in the higher portions the cedar (*Libocedrus decurrens*), sugar pine, and several species of spruce come in. The nut pine (*P. Sabiniana*) and the blue oak (*Q. Douglasii*) are especially characteristic of the lower altitudes, say up to one thousand five hundred feet to one thousand eight hundred feet; higher up, the yellow pine, sugar pine, black pine (*P. ponderosa*, *Lambertiana*, *Jeffreyi*), the two mountain live oaks (*Q. Wislizeni*, *chrysolepis*), and the black oak (*Q. Kelloggii*) predominate. The California buckeye (*Æsculus Californica*), as well as the madrona tree (*Arbutus Menziesii*), reach from the valley quite up to three thousand feet. There is usually a more or less dense undergrowth of shrubs, chief among which are several species of chaparral (*Ceanothus integerrimus*, *cuneatus*, *decumbens*), the beautiful manzanita (*Arctostaphylos manzanita*), the toyon (*Heteromeles* (*Photinia*) *arbutifolia*), California buckthorn (*Frangula Californica*), the poison oak (*Rhus diversiloba*), and the chamisal (*Adenostoma fasciculatum*). The presence or absence of these trees and shrubs, and their mode of development, indicate very closely the changes in the quality of the soils.

Agriculture in the Foothills.—In early times mining was the exclusive pursuit in the foothill region, and it is still of preponderating importance in the higher altitudes, although the prohibition of hydraulic gravel-mining has dealt it a heavy blow. When placer mining ceased to be very lucrative, a good many of the old miners took to farming, but mostly in a rather desultory way; while others, who had previous experience in farming and gardening, made an excellent business of supplying, from "truck" gardens established in the valleys, the necessities of the mining populations. The high quality of the red foothill soil, and the practicability of cultivating it to a considerable extent without irrigation, was a comparatively late discovery, and was first carried to its ultimate consequences largely on account of the inducements offered by the passage of the Central Pacific Railroad through one of the choicest portions of the foothill region. It was there demonstrated that up to three thousand feet, and even considerably higher in favorable exposures, the deciduous fruits, including the apple, pear, plum, prune, cherry, vine, and the small fruits, are at home, and yield fruit of specially high quality. This has been so well recognized that while in past years the fruit growers of other portions of the State have been unable to find a sufficient market for their fruit, the foothill fruits from the region adjacent to the Central Pacific Railroad, from Rocklin up to Colfax and Dutch Flat, have from the outset been steadily marketed at good prices, on account of their high flavor and good shipping qualities. The adaptation of the lower portions of the belt to the large-scale production of semi-tropic fruits—the fig, olive, pomegranate, and the citrus tribe—has been fully recognized only within the past eight or ten years, although the specimen trees have existed for many years without exciting special remark.

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Besides the various fruits, the cereals, alfalfa, clover, and all the usual crops and vegetables of warm temperate climates are being grown in the foothills, and succeed admirably whenever properly cultivated. Yet a large proportion of the market supplies consumed by the mining population is still brought from the valley; not because of any intrinsic disability of the region to produce them, but because the conservative habits and imperfect methods of the old miners who have taken to farming, too frequently fail to produce the good and lucrative results warranted by the generous soil and climate. With the infusion of a new population this state of things is rapidly changing for the better, and the salubrious climate brings many immigrants in search of health. But the limited experience thus far had as to the best varieties to be planted, as well as the best methods of culture, the use of irrigation, and many other doubtful points, rendered the early establishment of a culture experiment station for the foothills specially desirable.

Occurrence of the Several Soils.

The rocks from which the several soils of the foothills are derived usually occur in more or less irregularly shaped and often discontinuous belts, running approximately parallel to the general trend of the mountains, viz.: south-southeast to north-northwest; hence, in traveling on east and west lines, the several soil regions are usually crossed consecutively, but not always in the same order at different points. The cross-sections described below will serve to illustrate these facts.

Soils of the Valley Border.—It is necessary to premise that in the valley itself, on the east side of the Sacramento and Feather Rivers, the lands are but very partially of a purely alluvial character. Low ridges and swales at right angles to the rivers' course come in from the foothills, forming a gently undulating plain with a fall of from fifteen to twenty feet per mile, sometimes right up to the river channels. Nearly all these soils of the east side have a reddish tinge, showing the admixture of the red foothill soil, and demonstrating, by the way, that all these lands are well drained. In cuts ten to twelve feet deep, made by the sloughs, the reddish plains loam is seen to reach to six to ten feet depth, being then underlaid by gravelly substrata. The width of this class of profusely fertile valley land, east and west, varies considerably, according to the meanderings of the rivers. Near the city of Sacramento, where the main stream meets the American River on an eastward turn, but little of this valley soil occurs eastward of the crossing, and on the overland (Central Pacific) route we soon reach another class of lands, viz.: the

Gravel Plains or Bedrock Lands, which may be considered as the lowest member of the foothills belt, since they are underlaid by a non-alluvial, horizontally stratified formation of grayish and whitish clays, that with varying width extends from near Chico, Butte County, southward across the Mokelumne, and probably at least as far south as the Stanislaus River, and at some points ascends several miles into the foothills themselves. The nature of the materials of which this formation (doubtless of pliocene age) is composed, is well illustrated at Lincoln, Placer County, and at Ione, Amador County, where brown lignite coal, not very far advanced toward the condition of true coal, and rather impure, is mined, together with excellent, grayish-white potters' clay, which is shipped to potteries all over the State. Good potters' clay is not, however, the best material for soils and subsoils; hence, where it approaches the surface near enough to influence vegetation, the land, though not poor, is ill drained, and the soil heavy and

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of a tawny yellow; much of the surface is of the "hog-wallow" character,* and very gravelly; and during the wet season, and for some time thereafter, the surface is dotted with little ponds, forming an intricate network of slow streamlets, which keep up the green pasture for some time later than is the case on the alluvial lands. But when these surface waters once evaporate, the ground quickly dries up, and where tillage has not been very deep and thorough, injury from drought is very likely to happen. Hence a large proportion of these lands, however attractive to the eye in their spring garb, are largely as yet devoted to pasture, and form a comparatively little settled and mostly treeless belt between the valley and foothill lands proper, wherever the impervious clays approach the surface. Fortunately this is far from being the case everywhere, since both ancient and modern channels in great numbers traverse the belt, forming such fertile regions as the Ione Valley, and similar ones near Wheatland, Lincoln, and in the Mokelumne region. In Sacramento County this soil region is known as the "bedrock lands," and has been very successfully used for fruit culture, by the aid of the curious expedient described in the report for 1886, pages 23 to 25, viz.: the use of giant powder cartridges to break up the clayey "bedrock" beneath the holes in which trees are to be planted. The more general employment of this method, and the ultimate use of underdrains, will depend purely upon the increase of the value of fruit lands.

Only a few of the soils of this region have been closely examined as yet. One set of soil, subsoil, and "bedrock" or hardpan from near Florin, Sacramento County, has formed the subject of Bulletin 44 (reproduced in the report for 1886). An abstract of the results and discussion is given below. Three other soils belonging to this soil region, or to its border, have been analyzed and are likewise reported in the sequel.

No. 499. Red loam soil, from land near the railroad track, one and one half miles north of Wheatland, Yuba County. Glaringly orange red; stiffish, so that the dry lumps cannot be crushed between the fingers. When wetted darkens considerably in color and softens quickly; contains considerable coarse sand and some quartz gravel; becomes quite plastic on kneading. This is the soil of the undulating lands stretching from the foothills several miles into the valley, and but little above the general level of the latter; tills easily when taken in the right moisture-condition, but plows very cloddy when either too wet or too dry. Chiefly used for pasture and wheat growing, and yields, in good years, fifteen to twenty, sometimes as much as twenty-five bushels per acre; in poor years eleven to thirteen bushels, but never fails; responds very kindly to summer fallowing. Its natural vegetation is almost entirely herbaceous, with a few poison oak bushes.

The subsoil of this land is quite stiff, forming hard, vesicular lumps, streaked with deeper red than the general mass.

Bedrock Lands.—Two sets of materials representing these lands were received, agreeing substantially with each other, although from localities several miles apart, viz.: Mayhew Station, on the Sacramento Valley Railroad, and Florin, on the Central Pacific line. The arrangement of these materials is reported as follows:

1. *No. 858. Pale orange surface loam*, four to forty-eight inches thick.
2. *No. 949. Stiff brownish adobe*, three to twelve inches thick.
3. *No. 950. Brown or whitish hardpan*, one to ten inches thick.

*These "hog-wallows," though presenting the same general appearance of innumerable little, low mounds, dotting thickly a more or less level country, that is so familiar in Mississippi, Louisiana, and Texas, are manifestly due to somewhat different causes, which will be found discussed elsewhere.

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4. *No. 953. Brown or white coarse sand*, depth not known.

No. 858, the loam forming the soil, and ordinarily the subsoil of the region, is apparently identical in the two localities, and is scarcely distinguishable from the soils prevailing (*e. g.*, near Wheatland, Yuba County) in a corresponding position; it also agrees very nearly in the essentials of chemical composition.

The brown adobe, No. 949, which forms an almost uniform layer over the bedrock everywhere, has evidently been formed out of the latter in the course of time by the usual process of soil formation, and, as will be seen below, the two scarcely differ in composition more than might different portions of either from each other.

The "bedrock" hardpan, No. 950, differs somewhat in aspect in the two localities. At Mayhew Station it is a yellowish white, almost chalky, uniform mass, covered on top by a blackish, smooth, almost shiny crust an eighth of an inch thick, manifestly formed by the deposition of brown iron ore (limonite); it would, alone, effectually prevent the penetration of roots into the hardpan. The latter is quite compact and free from grit above, but downward gradually becomes more friable and sandy, and finally seems to pass into almost pure, sharp sand, at times of a strong rusty tint, but mostly white. Mr. Lubin states that this rock crumbles on exposure to the air.

At Florin the "bedrock" is less compact, of a rusty tint, and instead of the hard, shining crust on the surface, it is penetrated in all directions by blackish streaks of the iron ore. It seems more nearly ready to form the adobe than the material at Mayhew, and is more readily penetrated by roots, but in general character is very nearly alike.

These differences account for some differences in the experience had in this bedrock land in regard to the success of orchard trees planted on it. It is stated that they flourish for a few years, varying with the depth of the soil, but about the time that the roots reach and would need to penetrate the hardpan layer, they cease growing and often finally die. The question arises whether this is due simply to the impenetrability of the "bedrock," which prevents the roots from gaining access to a sufficient supply of moisture and plant food, or whether any injurious ingredients, or other conditions, play a part in the failure of the trees.

No. 1186. Loam soil, from the "gravel plains," northeast from Galt, Sacramento County; sent by J. H. Blaisdell, of Stockton, who gives the following information regarding it:

"The top soil is from six to eight inches in depth; then there underlies a clay (subsoil), which is about two feet thick. Then comes the hardpan, from six inches to a foot thick; underneath that is clay like the sample sent, of unknown depth—it has been dug into in sinking wells for a hundred feet, water being found at that depth; it is said to be moist all the way down. The red subsoil also holds moisture well, for parties cultivating it say they have never known it to become dry in the driest summer. The hardpan sent also was moist when dug (early in November, 1889), and was full of grass roots. The average grain product on this land is not above seven or eight bushels, although with good cultivation it has, in favorable seasons, yielded as much as fifteen bushels. Crop failures will occur in seasons that are either very wet or very dry, although the yield of straw is generally good. Looking at the land after plowing one would say that it should yield twenty-five to thirty bushels per acre."

The surface soil is a reddish brown loam, showing a great deal of gravel (quartz) from hazelnut size down, but very little coarse sand, being rather fine and silty. Dry lumps crush with some difficulty; on wetting, their

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color darkens materially and they soften quickly, becoming quite plastic on kneading.

The subsoil clay, No. 1187, is also very gravelly, lighter colored than the surface soil. Dry lumps crush readily, but on wetting darken but a little and soften more slowly than the soil, becoming less plastic on kneading than the latter; hence to call it a "clay" would seem to be a misnomer.

The "hardpan," No. 1188, is darker tinted than the subsoil; cannot be crushed between the fingers; contains no gravel. On wetting softens easily, and becomes very plastic on kneading. It is therefore a clayey material, but, as the sample shows, is penetrated by the grain roots.

No. 193. Loam soil, from Mr. Huffman's wheat farm, five miles north of Merced City. A light reddish brown loam; dry lumps crush with some difficulty, but when wetted soften quickly, and on kneading become quite plastic. No gravel, save smooth, round concretions of bog iron ore, from the size of buckshot down; also some coarse sand, consisting mainly of rounded quartz grains, with some well-weathered hornblende and a very little feldspar. The soil sample was taken to the depth of twelve inches, but the subsoil appears to be the same material for at least three feet. The surface of this land lies in gentle swells, on which are the characteristic "hog-wallow" hillocks, not very deeply impressed, and therefore not interfering materially with tillage even in fresh land, and almost disappearing after a few years' tillage. The wheat product has been from twenty-five to thirty-five bushels per acre on fresh land, in good years; but the product decreases materially after a few crops are taken off.

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Gravel Plains and "Bedrock Lands."

	Yuba County.	Sacramento County.				Merced County.
		Florin Section.			Galt.	
	No. 499. Red Loam, 12 inches. 1¼ miles north of Wheatland.	No. 858. Soil, 12 inches.	No. 949. Subsoil, Adobe, 3 to 12 inches thick.	No. 950. Bedrock, Hardpan, 1 to 10 feet thick.	No. 1186. Soil, 6 to 8 inches.	No. 193. Soil, 10 inches. Huffman's Place.
Coarse materials > 0.5mm	15.00	4.80			36.50	10.00
Fine earth	85.00	95.20			63.50	90.00
Analysis of Fine Earth.						
Insoluble matter	78.79	82.94	72.07	72.65	75.64	80.33
Soluble silica	3.80 } 82.59	6.28 } 89.22	7.51 } 79.58	6.12 } 78.77	8.70 } 84.34	4.35 } 84.68
Potash (K_2O)	.25	.28	.38	.43	.48	.35
Soda (Na_2O)	.04	.07	.16	.14	.10	.06
Lime (CaO)	1.02	.60	.52	.61	.21	.51
Magnesia (MgO)	.47	.23	.64	.95	.29	.59
Br. ox. of manganese (Mn_3O_4)	.02	.09	.02	.02	.04	.02
Peroxide of iron (Fe_2O_3)	5.81	1.91	5.10	5.65	5.36	4.77
Alumina (Al_2O_3)	6.28	5.42	9.44	9.31	5.88	6.17
Phosphoric acid (P_2O_5)	.04	.02	.05	.08	.04	.02
Sulphuric acid (SO_3)	.02	.01	.01	.01	.02	.01
Carbonic acid (CO_2)						
Water and organic matter	3.64	2.26	4.12	4.08	3.59	3.28
Total	100.18	100.10	100.02	100.05	100.35	100.46
Humus	.47	.46			.28	.37
Ash	.34				.81	.33
Sol. phos. acid		.02			.02	
Silica					.46	
Hygroscopic moisture (absorbed at 16 °C.)	4.81	2.60	7.70	8.70	3.67	4.21

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A glance over the figures representing the four surface soils in the foregoing table (Nos. 499, 858, 1186, and 193) shows that unlike the soils of the foothills proper, they contain a very large proportion (about 85 per cent on the average) of inert matter, mostly fine quartz sand; which, of course, depresses all the plant-food percentages to a corresponding degree. Were their texture a loose, sandy one, and the subsoil of easy penetration by the roots, this would not necessarily detract from their productiveness, although their phosphoric acid supply is unusually low. But being compact and somewhat difficult of penetration by roots, it follows that unless very thoroughly and deeply cultivated, and with favorable seasons, their product of cereal grains especially will necessarily be low. The Wheatland soil has the advantage of a considerable supply of lime; of the rest, only that of the Galt gravel plains may be considered deficient in this respect. At the same time, the soil last named has a very respectable supply of potash, while in the Wheatland and Florin soils this ingredient is in unusually low supply for California. The former has yielded fine crops of grain when fresh, but the diminution of the product has caused a search for better paying cultures; among these, fruit—particularly table grapes, apricots, and plums—would seem to be the most promising.

As regards the samples representing the "bedrock lands" about Florin and Mayhew Stations, it is curious to note, in the above analyses, that, notwithstanding the great differences in the appearance of the three materials, they do not differ widely in most points of their composition. The prominent points of difference are that the surface soil contains about 10 per cent more of inert matter (fine sand) than the other two, but much less iron, and only a very minute amount of phosphoric acid. The latter, however, increases very rapidly downward, the adobe containing more than twice as much as the top soil, and the "bedrock" again nearly twice as much as the adobe, or four times as much as the surface soil. The deficiency of the phosphoric acid in the soil is measurably offset by the fact that nearly all of it (.016 out of .019) is in an available condition, and hence the deficiency has not been much felt in the past; yet it does seem quite important that the relatively large supply in the lower depths should, if possible, be rendered accessible to the roots of trees. The supply of lime is nearly the same in all, and probably adequate, although more would be desirable in the stiff adobe.

It is certain that this desirable downward penetration of tree roots is not possible when, as near Mayhew Station, they encounter a hard, polished crust covering a very solid hardpan of several feet depth; and while at Florin the hard crust is less prominent and the material less solid, yet its condition indicates a want of drainage during the wet season, causing the formation of iron solutions, injurious to the root tips, exactly as in the other locality. It is obvious that the roots cannot go far during the season through such a substratum; and the breaking up of the latter by some financially practicable method would seem to be the necessary condition for the success of orchards.

Messrs. Weinstock & Lubin have attempted this on a somewhat extensive scale on their ranch near Mayhew Station, and Messrs. Kroll & Rutter at Florin, by blasting with either black or giant powder at the bottom of a hole bored with the auger to the depth of six feet, or even more. The shattering of the "bedrock" thus produced, at least when giant powder No. 2 has been used, seems sufficient to insure the welfare even of pear trees. The expense of this operation will, of course, vary, with the nature of the land and the number of trees planted per acre, from $30 to twice that amount, in case very thorough work is wanted.

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The kind of explosive to be used with the greatest advantage will naturally vary from place to place, with the nature of the hardpan, and will have to be ascertained by trial, which could best be made before the rains set in. But in view of the fact that the substratum of the "bedrock lands" is shown to be actually richer in plant food than the surface soil; that while in its natural condition it not only obstructs the passage of the roots mechanically, but also injures them by the formation of poisonous solutions in consequence of the stagnation of water, all of which can be relieved by the shattering of the substratum by means of judicious blasting, also giving the roots access to abundant moisture; it would certainly seem that in favorable locations, where land is valuable, this mode of rendering it available for fruit culture deserves most earnest consideration. Neither the adobe nor the "bedrock" should be used in the filling up of holes after planting, any more than a raw subsoil should be turned on the surface in other cases. But with the access of air and water to the shattered portion, the substrata will gradually go through the processes of soil formation; and their plant food will doubtless become available fast enough to insure the welfare and productiveness of an orchard for the usual period.

The "gravel plains" soil from the Galt neighborhood differs pointedly from those of the Florin region in the nature of its substrata, none of which are quite as clayey or impervious as in the bedrock lands, although, as it appears, a heavy deposit of red clay replaces the sandy strata said to underlie the "bedrock" in the latter. No heroic measures are called for in the gravel plains to render the substrata penetrable to roots; deep cultivation would probably accomplish most of the improvement needed in the mechanical condition of the land, and underdrains would relieve all trouble. Chemically the gravel plains soil suffers from a deficiency of lime, as well as from a low supply of phosphoric acid, though much of the latter is in a soluble condition, and with the good supply of potash explains the growing of good crops in favorable seasons. Liming would probably be the best paying mode of fertilization in these lands at the present time, and the turning in of green crops should serve to increase the very small proportion of humus. Until this is done small dressings of Chili saltpeter would doubtless be beneficial.

The Merced soil, while of commendable physical qualities, and endowed with fair proportions of lime and potash, is conspicuously deficient in phosphoric acid, so as to render it certain that phosphate fertilizers will be the first thing needed when the first productiveness is exhausted. Its supply of humus is also very low, a defect which should be treated as in the preceding case, by green manuring and the use of nitrate of soda when production slackens.

SECTIONS ACROSS THE FOOTHILLS.

Butte County Section.—While a number of soils from the valley portion of Butte have been examined and reported upon heretofore (see "Report of the College of Agriculture for 1882," page 20), the only soils from the foothill portion of the county thus far investigated are from the neighborhood of Oroville, notably from the lands that, at Thermalito Colony and elsewhere, have been devoted to the culture of citrus fruits. Two sets of soils were received from the neighborhood: one from S. S. Boynton, then editor of the Oroville "Register," and the other from Senator A. F. Jones.

The town of Oroville is situated near the point where Feather River emerges from the foothills proper into the plain, with a sharp turn to southward. On its right, or western, bank the river runs at the foot of a bluff, which, opposite Oroville, is from sixty to seventy-five feet above the river

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level, but to southward, within two miles, falls to only ten to twenty feet elevation; a gentle slope to the southwest continues for eight miles. Directly to southward of the town there is on the east side a stretch of valley or bottom land, forming a basin about three thousand acres in extent, much of which has been mined over for gold. This is bordered on the east by a bluff twenty to forty feet high. The bluffs on both sides show, in various modifications presently to be noticed, the "red foothill soil" seen elsewhere in the region.

The following samples have been examined, and in part analyzed:

No. 1088. Soil, from the bluff on the west side of Feather River, about one half of a mile west from Oroville; sent by S. S. Boynton. The soil-forming layer is here from three to ten feet in thickness, overlying gravel. The vegetation is usually oak (blue and white) and greasewood (chaparral?); in places also the nut pine, manzanita, and poison oak. The soil (sample taken to the depth of eighteen to twenty inches) is a glaringly orange-red loam, of fine texture, very little coarse sand, but some quartz gravel from one fourth of an inch upwards, and occasional slate fragments. Dry lumps crush with little difficulty between the fingers; when wetted they darken considerably (toward red) and soften quickly; on kneading become moderately plastic only.

No. 1109. Soil, ten to twelve inches depth, from the citrus grove of Thermalito Colony; sent by Hon. A. F. Jones. Much lighter in color than the preceding, of silty (powdery) appearance; dry lumps quite difficult to crush, and softening but slowly on wetting; also becoming but slightly plastic. Shows little coarse sand, but contains more or less of quartz gravel, well rounded. Seems likely to form hard surface crusts.

No. 1110. Soil, from block 100, Thermalito Colony, taken to ten to twelve inches depth; sent by Hon. A. F. Jones. Deep orange red; dry lumps hard to crush between fingers, but on wetting soften quickly, color darkening considerably; on kneading becomes quite adhesive, showing little coarse sand, but some quartz gravel. A clay loam, much heavier in tillage than No. 1109, but less liable to crust over.

No. 1111. Soil, from block 112, Thermalito Colony; sent by the same. Very similar to No. 1109, but a little darker colored; lumps when dry quite hard, soften but slowly when wetted; becomes more plastic than No. 1109, but less so than No. 1110, and seems in other respects to stand between the two. Like them contains little coarse sand, but more or less of quartz gravel. Not analyzed.

Two samples from the valley or bottom lands of Feather River in this region have also been received and examined:

No. 1089. Bottom soil, from the east bank of Feather River, about two miles south from Oroville and one fourth of a mile from the river. Taken to the depth of twelve inches, by S. S. Boynton. "The vegetation is nearly all oak (white, *Q. lobata*), but some sycamore and willow occur on the lower ground." A dark drab-colored sandy loam of fine texture, with much mica and a little gravel, but no coarse sand. On wetting darkens considerably and becomes slightly plastic.

No. 1176. Subsoil, "from high land above floods, near Feather River, in the extreme northern part of Sutter County," as stated by the senders, Messrs. White, Cooley & Cutts, of Marysville. Although this soil falls properly within the limits of the Great Valley, it is placed here for comparison with the preceding, which, although designated as high land, it resembles closely in its aspect, being probably old alluvium of Feather River. The depth of the soil stratum is stated to be six to twelve feet, with a clayey hardpan usually underlying. The land originally bore a heavy growth of

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white and live oak. The soil resembles altogether the previous number, though slightly heavier; the subsoil, which was analyzed, is of light, reddish drab tint; a light loam with much mica, little coarse sand, and no gravel. On wetting and kneading it becomes fairly plastic, showing more clay than the preceding number.

	No. 1109. Soil, 10 to 12 inches. Thermalito Colony, near Oroville.		No. 1110. Soil, 10 to 12 inches. Thermalito Colony, near Oroville.		No. 1088. Upland Soil, 18 inches. Near Oroville.		No. 1089. Feather River Bottom Soil, 12 inches. Two Miles South of Oroville.		No. 1176. Subsoil, 18 inches. Northeast Corner of Sutter County, near Feather River.	
Coarse materials >0.5mm	16.15		38.90		25.80		6.00		12.50	
Fine earth	83.85		61.10		74.20		94.00		87.50	
Analysis of Fine Earth.										
Insoluble matter	70.11	78.82	51.18	67.55	65.78	78.14	65.31	76.25	62.02	73.18
Soluble silica	8.71		16.37		12.36		10.94		11.16	
Potash (K_2O)	.42		.95		.18		.52		.70	
Soda (Na_2O)	.21		.57		.22		.57		.49	
Lime (CaO)	1.42		.57		2.04		2.04		2.18	
Magnesia (MgO)	.39		.42		.46		2.03		1.97	
Br. ox. of manganese (Mn_3O_4)	.06		.03		.04		.04		.02	
Peroxide of iron (Fe_2O_3)	9.56		9.90		6.97		6.73		8.01	
Alumina (Al_2O_3)	5.79		15.18		8.72		7.95		9.66	
Phosphoric acid (P_2O_5)	.07		.05		.04		.17		.10	
Sulphuric acid (SO_3)	.01		.01		.03		.02		.03	
Carbonic acid (CO_2)										
Water and organic matter	3.23		4.40		3.31		3.27		4.00	
Total	99.98		99.63		100.16		99.59		100.34	
Humus	.13		.45		.42		.85		.25	
Ash	.09		.80		.42		.52		.10	
Sol. phos. acid	.01		.02		.02		.04		.02	
Silica										
Hygroscopic moisture (absorbed at 15° C.)	3.15		6.54		4.32		2.84		4.86	

It appears from the aspect of these upland soils, as well as from the results of the analyses, that there is a great variation within short distances. The contrast between Nos. 1110 and 1088 is striking both in the matter of potash and lime, while as regards phosphoric acid, both alike are low and differ but slightly. No. 1109 stands between the two in respect to potash and lime, but much exceeds both in the matter of phosphoric acid, of which it has a respectable supply. There can be no doubt that material differences will be felt in the several neighborhoods represented by these samples in respect to the duration of fertility and the means of restoration or fertilization. As the soil No. 1109 seems to be the more generalized type, as well as the lightest, and, on the whole, the best, it is well that it should have been chosen for the location of a citrus grove. No. 1088 will undoubtedly soon be in need of potash fertilizers, and both it and No. 1110 will call for phosphatic manures when their first production slackens. Their character and depth manifestly adapts them better to fruit culture than to any other.

Of the alluvial soils from Feather River, No. 1088 is of high quality throughout, its phosphoric acid supply being especially notable, with plenty of lime and a good supply of potash. It should, in addition to other crops, make a specially good soil for prunes.

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No. 1176 falls behind the other only in respect to a lower supply of phosphoric acid, while even richer in potash and lime. As a somewhat heavier soil it will resist drought better than the preceding, whose capacity for moisture is somewhat low. Both are "as good as anybody need want."

No soils from the foothills to the eastward of Oroville have been received as yet.

Section of the Foothills of Yuba and Nevada Counties.—On a cross-section from Marysville east to Nevada City the "bedrock lands" belt is not over a mile in width, and is quite sharply defined, as rolling sheep pasture land, against the rich brown loams of the adjacent valley.

Immediately to eastward we enter upon a belt of slate soil, not as deeply red as it is farther inland, but strongly characterized by the sharp, lancet-like edges of the slate that jut out on all steep slopes or breaks of the rolling country. This appearance of the outer slate belt is very characteristic, from the head of the valley at least to Mariposa County, southward of which it is frequently hidden beneath the later formation there skirting the foothills. The red soil covers the ridges like a blanket, up and down the slopes, but is commonly somewhat deeper on one side than on the other, deepening as the streams are approached. This is notably the case on the border of the Yuba Valley, where that stream emerges into the plain, from gently rolling uplands, covered with deep, red loam, and timbered with sturdy, compact oaks and nut pine. It would be difficult to find a better representation of the lands of the lowest foothills than the ranches near Smartsville, and thence southward to Dry Creek, where (near Spenceville) we see the same copper-bearing slates as farther south (in Amador), on the eastern edge of the outer slate belt. An unusual feature here is the local occurrence of a peculiar sandy variety of the slate, which disintegrates more slowly than the usual kind and is not readily penetrable by roots, and gives rise to inferior lands, with shallow, sandy soils, treeless in their natural state, and not well adapted to fruit culture.

Inland from the slate belt (here from three to four miles wide) the "blue trap" appears, alternating with bands of slate lands, but on the whole predominant, in its usual form, for several miles on the road from Smartsville to Nevada City. The slopes of the ridges (which in the main run parallel to the trend of the mountains) are mostly covered with deep, red soil, well timbered with oaks and nut pine; but on their brows they sometimes show treeless tracts of stony, shallow soil, usually underlaid by a slaty variety of the blue rock. Passing on to eastward we find on the waters of Squirrel and Indian Springs Creeks a feature somewhat unique in the foothills: a broad body of valley lands, collectively designated as the Penn Valley and Indian Springs country; bounded on the east by the rocky ridge country, within which lies the old mining town of Rough and Ready, and on the summit plateau of which, a thousand feet higher than the valley lands in question, lie Nevada City and Grass Valley. The Penn Valley region has a soil differing from the typical kinds heretofore mentioned, being a brown clay loam originating from a granite-like modification of the blue rock, traceable into the latter by insensible gradations. The fertility of this loam, which covers the gently undulating country to a depth ranging from five to twelve feet, is attested by the groves of huge white oaks still occupying many knolls, as well as by thirty years' experience in cultivation, during which there apparently has been no sensible diminution in production, at least on the bottom lands of Squirrel Creek. The average altitude of this region is about one thousand five hundred feet; all deciduous fruits, as well as figs, have been produced at Indian Springs, and it is well worth while to test the success of the citrus tribe.

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A rather steep ascent in the course of three miles brings us to the top of the broad ridge or plateau on which Nevada City, Grass Valley, and, farther south, the new colony of Chicago Park, are located, at average elevations between two thousand four hundred and two thousand five hundred feet. Here is distinctly the region of deciduous fruits, especial excellence being claimed for the Bartlett pear. Just north of Nevada City a broken country with granite soil sets in, commingled with a good deal of the volcanic and gravelly materials forming the upper portions of the gravel mine territory; while southward and southeastward the red soils of the older slates and "bastard rock" alone prevail, forming a deep covering on the rolling plateau lands. Originally all these lands were covered with heavy pine, cedar, and spruce timber; at present the second growth, almost altogether of yellow pine already large enough to serve as mine timbers, covers the uncultivated lands. The country rises rather gradually to eastward, and some fine orchards have been planted at elevations of three thousand feet and over.

Soils of the Yuba-Nevada Section.—The following soils have thus far been more specially examined on this cross-section:

No. 1216. Soil, from the "lone tree tract" near Vineyard's place, in the lower foothills southwest of Smartsville, Yuba County. A cinnamon-colored, silty loam, the dry lumps crushing easily between the fingers; on wetting darkens slightly, becomes only fairly plastic, and would till shortly after a rain. Contains some gravel and coarse sand, but most of the soil is quite finely silty. Underlaid at twelve to eighteen inches by a sandy, calcareous shale, standing on edge.

No. 1226. Soil, from the slopes of the Yuba River, below Smartsville. A reddish brown loam, with some coarse sand, but little or no gravel; dry lumps crush between fingers with some difficulty; those of the subsoil not at all. On wetting it darkens only moderately, and the lumps soften quickly, in the subsoil almost instantly; both soil and subsoil become quite plastic on kneading, and doubtless make a tough mud. The locality borders on the Yuba River, toward whose valley the red loam steadily thickens; where the sample was taken it was twelve feet to bedrock. The virgin portion of the land is covered with a fine growth of sturdy oaks and some nut pine, and in cultivation has given fine crops of all kinds, including fruits.

No. 1218. Soil, from the upland of Penn Valley, at Montgomery's place, on Squirrel Creek. A dull, brown loam; the subsoil more reddish; dry lumps hard to crush. Darkens considerably on wetting, and when kneaded becomes very plastic; cannot be tilled when wet. Shows some coarse sand and a little gravel. The subsoil at this point reached to at least fifteen feet depth. Bears a growth of white and other oaks, of extraordinary size and sturdiness, generally together in clumps.

No. 1205. Bottom soil, from Wagoner's place, on Squirrel Creek, Penn Valley. A loam of light drab color; dry lumps barely crush between the fingers; becomes much darker on wetting, and shows an abundance of mica scales, but becomes only very slightly plastic. Shows a little coarse sand; does not effervesce with acids. The point at which this sample was taken is about a mile above Montgomery's place, where the preceding sample was taken. The bottom soil there is much darker than at Wagoner's, and has borne crops uninterruptedly for over thirty years.

No. 1207. Red soil, from near Reed's place, four miles south from Nevada City. A dark reddish-brown loam, probably representative of most of the ridge soils southward of Nevada City and Grass Valley; elevation about two thousand five hundred feet; originally covered with a heavy growth

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of spruce, pine, cedar, and black oak, at present with a vigorous second growth of yellow pine, already large enough for mine timbers. Dry lumps of the soil crush readily between the fingers; it darkens much on wetting, but becomes only slightly plastic on kneading, and would be readily tilled soon after rains. A little coarse sand and occasional rock fragments form part of the mass, which continues apparently unchanged to the bedrock, at depths varying in this neighborhood from two to eight feet.

Nos. 861 and 863. Soils, from the neighborhood of Grass Valley, Nevada County; sent by Mr. H. H. Hanssen, of Grass Valley, who thus describes their characteristics:

"No. 861 is the predominant soil around Grass Valley, and to the south and southeast. It covers all the hills that have a bedrock formation of slate or granite. The soil and subsoil layer varies in thickness from one to four feet, sometimes with a clayey subsoil, but oftener such soil as the sample lies directly upon the rock. The latter, especially in the case of granite, is soft and broken up, and admits roots readily to the depth of eight to ten feet. Trees and vines grow in it without irrigation. The natural growth is yellow and sugar pine, white, live, and scrub oaks, manzanita, and chaparral. When cultivated in grain and vegetables this soil does well for a year or two, after which crops are a failure unless manure is used; with the latter it does well." As the town and the mines near it lie (as usual) on the dividing lines between contiguous rock formations, the soil derived from these varies from hill to hill. Some, underlaid by talcose rocks, bear only stunted chaparral, while next to such knolls there may be a vigorous second growth of pine on the dark red soil.

The soil is a light loam, rather silty than clayey, of a deep red tint; dry lumps crush easily between the fingers. When wetted the color darkens considerably, and the soil becomes only slightly plastic, showing but a small amount of clay. Some angular rock fragments, and gravel up to buckshot size, are intermixed.

"No. 863, taken from the farm of D. Bryan, is the soil overlying the ancient gravel deposits, which are covered by it, sometimes with a lighter colored clayey subsoil, to the depth of six to ten feet, when a 'cement' formation is struck. It occurs chiefly to northward and eastward from Grass Valley; in fact, it covers all the hills under which the auriferous gravel beds are found. Sometimes the gravel cement comes to, or near the surface, when the ground becomes gravelly and barren. Its vegetation is of ranker and coarser growth than on the other soil. The normal forest consists of spruce, cedar, fir, different kinds of pine, and some black oak." The color of this soil is lighter than that of the first one, but apart from a smaller proportion of gravel, its physical character is about the same.

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Soils from Yuba and Nevada Foothills.

	Yuba County.		Nevada County.				
	Lower Foothills—Elevation, 600–700 feet.		Penn Valley—Elevation, 1,350–1,700 feet.		Upper Plateau—Elevation, 2,500 feet. Nevada City and Grass Valley.		
	No. 1216. Upland Soil, 12 inches. Lone Tree Tract, Southwest of Smartsville.	No. 1226. Upland Soil, 12 inches. On Yuba River, Below Smartsville.	No. 1218. Oak Upland Soil, 12 inches. Montgomery's.	No. 1205. Bottom Soil, 12 inches. Squirrel Creek, near Wagoner's.	No. 1207. Soil, 12 inches. On Ridge, near White's, South of Nevada City.	No. 863. Soil, 12 inches. Ridges, South of Grass Valley.	No. 861. Soil, 12 inches. On Aurif. Gravel, North of Nevada City.
Coarse materials > 0.5mm	20.00	30.00	15.00	2.00	6.00	5.60	12.60
Fine earth	80.00	70.00	85.00	98.00	94.00	94.40	87.40
Analysis of Fine Earth.							
Insoluble matter	57.42	61.67	37.04	48.63	14.01	26.96	43.81
Soluble silica	13.53 } 70.95	7.84 } 69.51	20.82 } 57.86	17.14 } 65.77	17.83 } 31.84	10.95 } 37.91	11.37 } 55.18
Potash (K_2O)	.19	.52	.47	.31	.21	.15	.16
Soda (Na_2O)	.07	.24	.13	.35	.13	.21	.17
Lime (CaO)	3.50	1.45	.96	2.42	.36	.33	1.29
Magnesia (MgO)	.86	.99	.88	1.95	.40	.30	2.19
Br. ox. of manganese (Mn_3O_4)	.02	.04	.04	.04	.03	.07	.03
Peroxide of iron (Fe_2O_3)	13.39	18.27	14.98	16.36	17.86	8.25	8.25
Alumina (Al_2O_3)	6.76	3.22	13.41	6.41	28.74	36.38	21.87
Phosphoric acid (P_2O_5)	.07	.09	.11	.06	.15	.09	.03
Sulphuric acid (SO_3)	.01	.02	.01	.01	.01	.07	.10
Carbonic acid (CO_2)							
Water and organic matter	4.49	5.50	11.26	6.76	19.85	16.48	11.16
Total	100.31	99.85	100.11	100.44	99.58	100.24	100.43
Humus	.58	.66	2.04	.58	4.15	2.89	2.37
Ash	.58	.62	1.36	.54	.85	.76	.71
Sol. phos. acid	.02	.07	.08	.02	.05	.05	.02
Silica	.40	.43	.59	.40	.20		
Hygroscopic moisture (absorbed at 14° C.)	3.67	8.04	7.92	7.32	12.01	14.20	8.20

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Of the soils in the foregoing table, the first (No. 1216) is distinctly a "sedentary" one, formed by the disintegration of the underlying sandy, calcareous shale, which is a local and exceptional feature of the "outer slate belt." Its lack of sufficient depth disqualifies it for fruit culture, and for other crops it needs irrigation, as the roots penetrate the shale only with difficulty. It would doubtless be gradually deepened by cultivation. Its high proportion of lime and fair supply of phosphoric acid offset in a measure its deficiency in potash—the first, doubtless, that will become apparent in cultivation. It is shared by the soils of the higher country, around Nevada City.

The soil of the slope lands on the Yuba, below Smartsville, although having a smaller percentage of lime, is yet well supplied with that important substance, as well as with potash and phosphoric acid, the more as the latter appears to be almost wholly in the easily soluble form. The latter point doubtless contributed materially to the remarkable thriftiness shown both in the natural vegetation and the crops grown on this soil, which undoubtedly constitutes the most ancient alluvium of the Yuba Valley, although now high above the bed of the river. Its high absorptive power secures it against serious injury from drought, or hot winds; but irrigation will best bring out its productive capacity in this as in other regions of the foothills. With its aid, orange trees have attained large size on this soil, as well as elsewhere in the Smartsville region, where, in one case, a highly productive deciduous orchard is being pulled up in favor of more such orange trees as already occupy a part of the ground, and are proving extremely profitable.

Soils quite similar to this extend some distance on either side of the Yuba, and, as the record shows, also upstream and on its tributaries. The upland soils of Penn and Indian Springs Valleys, while differing in some respects from these of the Smartsville region, justify, by their high and continued production, the indications of their natural tree growth as well as of trees that, planted since the occupation of the country, have grown to unusual size and girth. Here, as in the Smartsville region, an unusual proportion of the phosphoric acid present is in the easily soluble form; potash about the same at both points, but lime one third less, yet in ample supply, as is evidenced by the strongly calcareous character of the bottom soil of Squirrel Creek (No. 1205), although the sample analyzed does not represent the best of the bottom land, and is lower in nearly all other points than the adjacent upland soil (No. 1218). The latter has the advantage of the Smartsville soil in an unusually high proportion of humus, which also becomes manifest in the dark bottom lands adjoining the knoll at Montgomery's. The land of the Indian Springs country is practically the same as that in Penn Valley, and the same proofs of high productiveness and durability exist there.

Of the three soils from the Nevada City and Grass Valley plateau, two (Nos. 1207 and 863) are very much alike and doubtless represent the same general soil region, though sampled by different persons and in different localities. Potash is low in both, quite deficient in No. 863; lime is unusually low for California soils, though not absolutely deficient, and (as shown by direct determination) present in the form of lime carbonate to the extent of one tenth of the total, or .04 per cent, which is quite as much as soils of much higher totals of lime have actually present in active form. As to phosphoric acid, it is exceptionally high in No. 1205, and equal to that of the Yuba slope soils in the lower country. In the same soils humus is exceptionally high, though lower in No. 863 than in No. 1205; and the

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absorptive power for moisture is surprising, considering that both are to be classed as fairly light loams in tillage.*

The analysis of No. 861 fully justifies its reputation as a soil much inferior to those represented by Nos. 863 and 1207; for here both potash and phosphoric acid are deficient, while lime is in relatively large supply. Its phosphates appear, however, to be mainly in the readily soluble form, as in the other two soils, so that a deficiency does not appear immediately upon being taken into cultivation. It is, however, well known that these "cement" soils are much less durable in cultivation than the slate soils, and fruit is their best adaptation.

There can be little doubt that the quick giving-out of these soils under cultivation, as reported by Mr. Hanssen, is due to the exhaustion of the available potash; hence potash fertilizers, such as wood ashes and kainite, are indicated for all three; and for the lands represented by No. 861, phosphates will be in order at the same time, whenever production languishes. The abundance of humus present indicates that nitrogenous fertilizers will not be wanted for some time, and lime also would at present be of no advantage.

Taken as a whole, this Yuba-Nevada section of the foothills is a remarkable one for the large proportion of available land it presents, and the high quality of the soils in their several adaptations.

Section along the Central Pacific Railroad; Sacramento to Colfax.—While in the section from Marysville to Nevada City, as has been seen, the clay lands of the valley border are followed by an outer slate belt several miles wide, which, in its turn, is succeeded, inland, by a wide area of "blue trap," intervening between it and the older slates and granites that form the matrix of the typical soils, we find in Placer County, on the overland route, but a very slight representation of the exterior slate belt; but a short distance intervening between the clay or "bedrock" lands of the valley border and the granite lands of Roseville and Rocklin, and farther south of Folsom. Following the railroad we continue in granite until we pass Newcastle; we then enter and continue within the typical red foothills with slate bedrock until, near Colfax (two thousand five hundred feet elevation), the volcanic tufas and lavas on the higher ridges begin to form a large ingredient of the soil, and dilute, as it were, the typical material. The "blue trap," though not entirely wanting in this cross-section, appears to be confined to a narrow, cobble-bearing belt just east of Newcastle; while in the town itself granite rocks crop out. But to southward there is a rolling upland region, well settled and yielding the fine shipping fruits for which this locality, as well as its next neighbor to eastward—Auburn—are specially noted. At the latter point the typical slate soil prevails, which was shown by one of the earliest analyses made at this station (Report 1879, p. 21) to be of excellent chemical and mechanical composition,

*The explanation of the latter point seems to lie in the extraordinary amount of alumina shown to have been dissolved by the acid used in the analysis; quite out of proportion to the silica set free by the same action and shown as soluble in soda carbonate solution. For clay (kaolinite) the silica should relate to the alumina as 1:1.15; whereas here the ratio is (in No. 863) as 3:1.1—that is, there is nearly three times as much alumina as could be combined with the silica into kaolinite. The extraordinary amount of water expelled by ignition (approximately, 16.48 less 2.89—the humus—equaling 13.59 of water, of which only about 1.2 can be credited to the clay corresponding to silica, and to the ferric hydrate, etc.). There is thus at least 12 per cent of water to be accounted for, which would be just the amount corresponding to the whole of the alumina considered as hydrate. There can be no doubt that a very large proportion of it is thus contained in the soil, and this accounts for its slight plasticity in comparison with other soils showing much less dissolved alumina—*e. g.*, No. 1226, from the lower Yuba region, in which only 3.22 of alumina was dissolved under the same conditions. Similar reasoning applies to Nos. 1207 and 861, the latter having nearly twice as much alumina as can be combined into clay with the silica soluble in boiling solution of sodium carbonate.

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although, as in all the slate soils, its potash supply is not very high. But in the matter of phosphates it exceeds most of the soils of the State, and the continued high production on the old lands justifies the analytical forecast of its durability. The following descriptions and analyses of soils from this section will convey an idea of its characteristics:

No. 766. Granite soil, from near Pino Station, Central Pacific Railroad, Placer County; sent by Mr. E. W. Maslin, of Sacramento, who thus describes the general character of the country:

"There are about eighty square miles of such land lying between Boulder Ridge and the North Fork of the American River, and between Roseville on the south and Auburn Ravine on the north. The ground is gray when dry; when damp, brown or reddish. In places the soil is nine to ten feet deep; in some places not over one foot. The subsoil also varies in depth and character. On the hills the subsoil rests on a red, rotten granite, into which the roots of trees and shrubs penetrate. It has been dug with the pick to the depth of twenty feet. In the valleys there underlies a gritty clay, here called 'cement,' but also penetrable by roots. Water is within ten to twelve feet of the surface on the hills in summer. The natural growth is live oak, white oak, Digger and nut pine, chaparral eight to ten feet high, abundance of poison oak, and California 'holly' (red haw, *Photinia*)."

Specimens of vine canes, the growth of one season, accompanying the soil samples, showed a very good length, although planted late in the dry season of 1881–82, and never irrigated.

This hill soil, which seems to be the typical one, is a reddish gray, sandy loam, the sand mostly coarse, and consisting largely of granitic debris; it should till easily at all times. The subsoil, below the depth of twelve inches, is somewhat lighter colored and more sandy. The soils from the depressions or valleys seem to differ from the hill land mainly in being somewhat heavier and also of a darker tint.

No. 764. Valley soil, from near same locality as No. 766. A brownish dun-colored, rather sandy loam, darkening materially on wetting, and becoming but slightly plastic. Contains much coarse granitic debris. Sample taken to the depth of twelve inches.

The subsoil of this land is more reddish and somewhat sandier than the surface soil; the sand being decomposed micaceous granite, increasing downward. Beneath the subsoil, at depths varying from three to ten feet, is a porous, sandy hardpan ("cement"), quite coherent from clayey binding material and not readily penetrable by roots. Beneath this comes "rotten" granite (sometimes to twenty feet depth), in which the feldspar masses are kaolinized.

No. 51. Red surface soil, from near Auburn, Placer County, taken twelve inches deep; sent by Mr. N. S. Prosser, of Auburn. Original vegetation, oak, pine, manzanita, and chaparral.

This is a fair sample of the red soil of the placer mines, which seems to contain a small amount of gold everywhere, and has been washed on a small scale ever since the first discovery of gold in California. It is of a dark orange color, rather light in tillage, and pulverulent when dry, forming a very fine reddish dust. It contains throughout numerous fragments of slate, more or less decomposed, of all sizes, and is usually underlaid by the same, or its debris, at a variable depth, rarely less than several feet, unless lying on steep slopes. The soil becomes but slightly plastic on wetting, and can be worked soon after rains; its color darkens considerably on wetting. When dry its lumps are easily crushed between the fingers.

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Nos. 976 and 977. Soil and subsoil, from the neighborhood of Colfax, Placer County; sent by Mr. M. Lobner of that place. "The country rock in this neighborhood is slate, which is always found to be standing on edge or slightly slanting from the perpendicular, and being, as the samples sent show, very much decomposed to a considerable depth (rarely hard and bluish); it is readily penetrable by roots. It lies at depths varying from ten to forty inches below the surface, is of a grayish white tint, and is directly overlaid by a bright orange subsoil—a clayey loam, mingled more or less with fragments of bedrock, the latter decreasing toward the surface, until in the brownish red surface soil, which forms a layer averaging about six inches in thickness, but very little rock material can be seen. The soil is easily tilled, and when well cultivated always shows moisture at a depth of from two to four inches during the dry season; hence no irrigation is needed. The natural growth is the foothill pine, black oak, and manzanita, with some chaparral, and very generally some tarweed." (The latter is in this case the *Chamæbatia foliolosa*, a member of the rose family, which prevails extensively in the central and northern foothills of California.)

The change of the surface soil to the color of the subsoil occurs at from four to five inches in depth; but, according to directions, the surface soil sample was taken to the depth of six inches. Only a partial analysis of this layer was made, the most important material in connection with cultivation being manifestly the subsoil.

The soil and subsoil examined are of a light reddish brown tint, quite unlike the slate soil of the Grass Valley neighborhood. Dry lumps crush with little difficulty; on wetting the soil it darkens in color, softens quickly, and on kneading becomes only moderately plastic. Both soil and subsoil contain a good deal of more or less angular gravel, *not* fragments of the underlying rock, and evidently transported to some extent. The material shown in the railroad cut in the town appears to be more nearly related to the tuff materials than to the regular slate bedrock.

The two granite soils from Pino Station show the usual large amount of inert material (granitic sand or debris), which naturally depresses the plant-food percentages. The valley soil differs from that of the ridges, as might be expected, in somewhat higher percentages of lime—of which substance, however, there is enough in both—and of phosphoric acid, of which the supply is small in both, and will doubtless be the first deficiency to be supplied. Potash is present in adequate amounts, and humus is in fair supply, especially in the valley soil, causing its higher absorption of moisture as compared with the ridge soil. In both, however, that factor is low, hence irrigation would doubtless be very beneficial to the thrifty growth of the crops. The somewhat slow progress of vines and trees in the granitic soils of the foothills is at many points a matter of popular remark and complaint.

The Auburn soil—a typical slate soil—differs from the granite soils of Pino in one very essential respect: it has, even on the ridge land, over five times as much phosphoric acid as the soil, and four times as much as the subsoil, derived from the granite. In other respects it does not differ widely; but its well known high production, both in quantity and quality, and its thriftiness, confirm the forecast given by the analysis. Practically the same soil prevails near Newcastle, and to the southeast of Penryn—all localities noted for the production of fine shipping fruits.

The soils around Colfax are somewhat variable, since the lower ridges have the blue slate bedrock, while the higher ones either consist of, or are capped with the so called lava, more properly volcanic tuff, in various

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degrees of consolidation. It is probable that the soil and subsoil examined (Nos. 976 and 977) represent the latter class, whose predominant growth of pine indicates its poverty in lime, as shown in the analysis. The land is well supplied with potash, fairly with phosphoric acid, and has a high percentage of humus, and retention of moisture. The ease with which roots can almost everywhere penetrate to great depths in the subsoil and underlying soft bedrock, renders it well adapted to the growth of fruits without irrigation. As grain land it would probably not hold out long.

Soils of Section along the Central Pacific Railroad, in Placer County.

	Granite Soils.		No. 51. Slate Soil, 12 inches. Auburn.	No. 976. Soil, 0 to 6 inches. Colfax.	No. 977. Subsoil, 6 to 21 inches. Colfax.
	No. 766. Hill Pine.	No. 764. Valley Station.			
Coarse materials>0.5mm	22.40	22.50	13.90	----------	21.20
Fine earth	77.60	77.50	86.10	----------	78.80
Analysis of Fine Earth.					
Insoluble matter	78.94 } 85.22	75.05 } 84.87	} 69.52	----------	67.69 } 75.74
Soluble silica	6.28 }	9.82 }		----------	8.05 }
Potash (K_2O)	.65	.47	.38	----------	.49
Soda (Na_2O)	.30	.42	.07	----------	.14
Lime (CaO)	.76	.99	.96	----------	.25
Magnesia (MgO)	1.28	.65	1.09	----------	.53
Br. ox. of Manganese (Mn_3O_4)	.09	.03	.39	----------	.18
Peroxide of Iron (Fe_2O_3)	2.30	3.47	12.42	----------	3.85
Alumina (Al_2O_3)	6.82	5.71	10.97	----------	13.32
Phosphoric acid (P_2O_5)	.03	.04	.16	----------	.06
Sulphuric acid (SO_3)	.02	.05	.01	----------	.03
Carbonic acid (CO_2)	----------	----------	----------	----------	----------
Water and organic matter	2.60	3.58	5.14	----------	5.41
Total	100.07	100.28	101.11	----------	99.99
Humus	.51	.93	1.14	2.10	----------
Ash	.33	.29	1.12	.58	----------
Sol. phos. acid	----------	----------	----------	.02	----------
Silica	----------	----------	----------	----------	----------
Hygroscopic moisture (absorbed at 15° C.)	2.14	2.70	3.17	----------	6.00

Foothill Section in Amador County.—Approaching from the west the foothill spurs within which the Ione Valley lies, the gravel plains (see above) break into rolling land, and the reddish soil stratum becomes thicker and deeper tinted. The Ione Valley is an extensive area of agricultural land, almost surrounded by hills, traversed by several streams, which have deposited the red soil of the foothills, commingled or alternating with that of underlying clay formation, upon the valley floor. It is therefore not easy to obtain a representative sample for the whole valley, most of whose reddish or chocolate-colored soils are under cultivation and have yielded excellent results to its owners; while where the whitish clay enters largely into the soil-composition the results of culture are not nearly so satisfactory.

Eastward of Ione the clayey formation that underlies the gravel plains and lignite beds ascends into the hilly country proper, and continues, for perhaps a mile inland, to form the subtrata of the land; with the usual result that the region so occupied is nearly treeless, save that here and there a large pine has inserted its roots in vertical cracks accidentally formed. The general surface is covered with low, stunted chaparral, chamisal, and

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some manzanita—all evidently the worse for lack of moisture, the ascent of which, together with the penetration of the roots downwards, is cut off by the horizontal, impervious beds of clay and claystone.

How far to the north and south this arid clay upland extends, I have not been able to ascertain. Proceeding east there is a notable change in the aspect of the landscape so soon as the vertically bedded slate begins to appear as the substratum of the soil; trees become abundant and vigorous, the chaparral and chamisal reach overhead, and poison oak of rank growth is everywhere. The slate of this outer belt (supposed to belong to the Permo-jurassic time) is conspicuously softer than that of the interior, and often becomes almost a clay shale, so as to form heavy black clay soils or "black adobe;" at other points it is a fair roofing slate.

A sample of the red subsoil of the outer slate belt has been analyzed. The samples were sent by Mr. Thomas S. Crafts, of Ione, and its analysis and discussion is given in connection with those of the station, below. Near the eastern edge of this slate belt especially, it is here as elsewhere more or less impregnated with copper, which in the form of copper pyrites has given rise to extensive mining operations. Everywhere, however, it forms a productive soil, but not as deeply colored as are usually the soils of the inner and older slate belt. The two are here separated quite widely by a plateau area about seven miles wide east and west, on which the country rock is the "blue trap" or diabase in several modifications; always extremely hard, though often of a definite slaty cleavage or bedding, and by its disintegration forming a deep orange-red, clayey soil, the fertility of which is abundantly shown both by the natural tree growth and by the results of cultivation wherever a sufficient depth of soil exists. For between two and three miles on the road from Ione to Jackson, this soil is so thickly inlaid with cobbles of the blue rock as to render cultivation without removal of the rocks impossible; but so good is the soil that the "cobble belt" is fast being brought into cultivation, the cobbles being formed into stone fences. It appears that when the rocks now on the surface are once removed, the soil beneath is comparatively free from them, and of good depth.

Towards Jackson the dense, almost glassy "blue trap" gradually becomes more granular, and at some points seems to form a transition into granite, alternating with bands of slate; at the same time the soil becomes deeper and less heavy, and at Jackson we reach the "inner" slate belt, near the contact of which with the other rocks important mineral lodes are worked. Here the soil, underlaid by the hard (supposed paleozoic) slates is of the deepest of "red" tints, and corresponds in character with that which, farther north, in El Dorado and Placer Counties, bears the choicest fruits.

The *granite areas* appear to be quite irregularly interspersed among the slate, and may in general, where the granite alone forms the soil, be recognized by their almost exclusive growth of undersized yellow pine. In such localities it is not uncommon to find the subsoil formed of granitic debris pure and simple, so that in digging one gradually comes down to the solid, undecomposed rock. Very desirable soils are formed where the granite and blue trap, or the slate, both contribute to the mass, as is often the case on the long slopes that characterize most of the ridges of the region, and more especially the rolling lands south and southeastward of Jackson, toward the Mokelumne River.

As the soils on this cross-section of the foothills have not as yet been as fully investigated as at some other points, the details of the examination of the soils of the station tract will be given, in connection with the description of the latter, below.

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The foothills south of Amador have only been casually observed thus far. Those of Calaveras County resemble closely the Amador section just discussed, and there, as well as in Tuolumne, are of considerable width and capable of growing excellent fruit. In Mariposa the foothills belt narrows considerably, and the red soil, near Merced Falls, is of quite a different character from that of the counties adjoining to northward, being a heavy red clay soil so thickly packed with gravel that it is difficult to penetrate; a characteristic that is again found on the extreme north, near Chico, Butte County. There, as in Mariposa, the lower foothills do not present the gentle slopes of Amador, Placer, and Yuba, but as seen from the valley appear rather rugged and rocky; and the valleys rather than the hills themselves have mainly been taken into cultivation. The subjoined analyses afford some insight into the nature of these soils:

No. 190. Red loam soil, from the foothill slopes near La Grange, Tuolumne County. Vegetation, scattered oak timber (mainly "blue" and white oaks), with little or no underbrush save some poison oak; also grass and flowers. A moderately heavy, glaringly orange-red loam, tilling well unless when very wet; but little gravel; not much in cultivation save in gardens, in this neighborhood; makes fine vegetables and fruits. Sample taken to twelve inches depth.

No. 68. Valley adobe soil, from near Mount Pleasant, Tuolumne County; sent by Mr. J. Taylor, of that place. A black, heavy clay soil, now largely covered with mining slum, but originally very productive. Similar soils occur in the foothill valleys of Tulare. (See "dry-bog" soils, below.)

No. 191. Red foothills soil, taken two miles north of Merced Falls, on the La Grange road, Merced County; depth, ten inches. A rather heavy clay soil, considerably mixed with gravel, brownish red; natural vegetation, grass, and scattered "blue" oaks; chiefly pastured at present, but capable of producing fifteen to twenty bushels of wheat per acre, in good seasons, and with good tillage.

No. 196. Red gravelly soil, from rolling land eleven miles north of Merced City. Dark brown, rather fine and silty, but more than half of the mass is gravel, mostly flattened—slate and quartz—from inch size down. Dry lumps hardly crush between the fingers; when wetted it darkens but little and softens rather slowly, becoming only fairly plastic on kneading. This soil represents a promontory of rolling foothill land, which projects out into the valley from near Merced Falls toward Atwater, on the Southern Pacific Railroad, gradually flattening out and having on its flanks the light-colored loam lands represented by the soil from Huffman's (No. 193 above). The surface, even to the hilltops, is deeply scored into "hog-wallow" mounds, separated by a maze of little channels filled with gravel or oftentimes with cobblestones. The land is treeless and free even from underbrush, but bears good sheep pasture in the spring. Little or none of this land is under cultivation thus far, doubtless on account of the difficulty of breaking up the gravelly mass.

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Soils of the Southern Foothills.

	Tuolumne County.		Mariposa County.	Merced County.
	No. 190. Red Loam Soil. La Grange.	No. 68. Valley Adobe Soil. Mount Pleasant.	No. 191. Red Foothill Soil. Merced Falls.	No. 196. Red, Gravelly Soil. Hog-wallow Hills, 11 miles North of Merced City.
Coarse materials > 0.5mm				
Fine earth				
Analysis of Fine Earth.				
Insoluble matter	67.92 } 74.88	{ 56.61 }	73.35 } 77.86	79.08 } 84.62
Soluble silica	6.96 }		4.51 }	5.54 }
Potash (K_2O)	.35	.19	.38	.21
Soda (Na_2O)	.13	.14	.13	.11
Lime (CaO)	1.54	.68	.35	.39
Magnesia (MgO)	.72	13.74	.84	.36
Br. ox. of manganese (Mn_3O_4)	.03	.08	.07	.03
Peroxide of iron (Fe_2O_3)	7.88	{ 18.43 }	6.96	3.90
Alumina (Al_2O_3)	9.86		8.81	6.66
Phosphoric acid (P_2O_5)	.09	.07	.07	.05
Sulphuric acid (SO_3)	.01	.01	.02	.01
Carbonic acid (CO_2)				
Water and organic matter	3.77	9.84	5.06	4.14
Total	99.62	99.79	100.55	100.57
Humus	.72	1.61	.71	.76
Ash	.45	.40	.47	.53
Sol. phos. acid				
Silica				
Hygroscopic moisture (absorbed at 15° C.)	5.42		6.11	5.00

It will be noted that the two red soils in the preceding table, while differing widely as regards the contents of lime, are not far apart in their contents of potash and phosphoric acid. Of the two the La Grange soil is undoubtedly the better, owing to its higher proportion of lime and phosphoric acid, and while not rich in potash does not fall far behind the average of the Nevada soils in this respect. The supply of humus is satisfactory in both. The lime contents of No. 191 are quite low for so heavy a soil, but with good cultivation and adequate depth it should do well with such fruits as apricots and plums.

The adobe soil is quite remarkable for its unusually low contents of potash and a most extraordinary proportion of magnesia, exceeding therein any soil heretofore analyzed, within my knowledge. It probably is derived from some extended exposure of magnesian rocks in the upper portion of the valley. The soil has fair proportions of lime and phosphoric acid, as well as a high one of humus; and while the potash holds out should produce well, but should have most thorough tillage.

The gravelly soil from the "hog-wallow" hills of Merced stands just at the limit of deficiency for potash and phosphoric acid in a soil of its texture, and while the contents of lime and humus are good, the land does not invite settlement until better land shall be more scarce, because of the excessive proportion of gravel and cobbles, which render tillage difficult. In time it will doubtless be utilized for fruit; best probably for wine grapes, of which it would yield a high quality. With good tillage, peaches and almonds would doubtless find this a congenial soil.

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Location of the Foothill Station.—The selection of a fairly representative location for this station was a matter of no little difficulty, in view of the wide extent and varied character of the foothill region. It was clearly necessary to place it somewhere near the geographical center, north and south; not too near the Great Valley; not so high up as to do injustice to the lower or "semi-tropic" belt; nor so low as to leave out of the scope of experiments the "snow belt," with its excellent deciduous fruits. Again, it was necessary to avoid as much as possible any local influences that would vitiate the general results; and it was desirable to have within the station limits at least two of the principal soil varieties of the region, and to have command of irrigation water without too great expense in bringing it to the land.

The geographical consideration pointed to the counties of El Dorado and Amador, and as pressing and advantageous offers were early received from the latter county, through the energetic and intelligent efforts of State Senator A. Caminetti, a somewhat extended examination of that county and of the various localities offered was made in the spring of 1888 at two different times. One of the prominent governing facts elicited here, as elsewhere in the region, was that the more tender vegetables and fruits are earlier and resist the winter's cold better on the higher plateau lands than in the valleys, or even on the valley slopes. This pointed to a plateau site at a suitable elevation as best adapted to yielding results of general value to the region at large. Many facts pointed to the elevation of one thousand eight hundred to two thousand feet as the one where the citrus trees had withstood best the severe winter cold of 1887–88; and among the sites offered at or near that altitude there was one offering the additional advantage of closeness to the Amador ditch and the ready inclosure of the two typical soils—granite and slate—within a tract of twenty or thirty acres. A suitable tract of the former area was offered by Senator Caminetti on behalf of Hon. John Boggs, of Colusa; but as this tract could not include all the desirable representation of the granite soil for duplicate experiments, nor the best sites for building, two additional tracts of about six acres each were donated, respectively, by Mr. Daniel McKay, on the north, and by Messrs. Trabucco and Oneto, on the east, the latter receiving some compensation for standing timber. Thus a tract of practically thirty-six acres, about equally divided between the two chief soil varieties of the foothills, was secured in a location as nearly free as possible from local influences, being on a ridge level with or a little higher than any near it; within five miles of the town of Jackson, the county seat, which itself can be reached in two hours from Ione, the present railroad terminus, but is likely to be reached by rail itself before many years. While it would have been desirable to have the station nearer an existing railroad, it would not have been easy to combine the advantages realized in the present location at any point where the land would have been likely to be available by donation. While the greater part of the tract lies above the water level of the Amador ditch, the fact that the ditch company offered the use of the water free of charge, and agreed to the placing of a water power for pumping in the ditch where it traverses the tract, relieves the station from a current expense representing considerably more than the interest upon the cost of the pumping plant; and the liberal offers made by the citizens, of pecuniary aid in carrying out the improvements, over and above the erection of the buildings, created the additional inducement of the sympathy and coöperation of the population, an advantage not to be lightly estimated in work of this kind.

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The recommendation of the Director, based upon the above considerations, that this location be accepted as suitable for the Foothill Station, was approved by the Regents at a meeting held in April, 1888; and immediate steps were taken to place the establishment on a working basis.

Surface Conformation, Soils, and Natural Vegetation.—The plat of the station tract, given further on, with contour lines for intervals of twenty feet,* shows the form and relief of the station grounds. It will be noted that it embraces three hills, on the highest of which, one hundred and sixty-eight feet above the ditch level, the dwelling house is located. The main upland portion has for its center the reservoir hill, one hundred and forty feet above the ditch level, on the top of which the slate bedrock crops out, into which a reservoir of twenty-five thousand gallons capacity has been excavated, from which practically all the available land of the station can be irrigated. A line laid nearly due east and west, along the northward slope of the reservoir hill, about twenty feet below the summit, divides the red slate soil from the granitic, which occupies the main portion of the northern slope, and all of the valley land on either side of the ditch, or about two fifths of the whole tract.

The land had been partly cleared of its natural timber for use in charcoal burning, but all the species originally there were still represented, and the large stumps proved that the trees had been of good dimensions, especially on the slate soil. On the southwest slope, where the red soil was sampled for analysis, the following species were noted at the time:

Yellow, sugar, and nut pine (*Pinus ponderosa, Lambertiana, Sabiniana*), the two mountain live oaks (*Quercus Wislizeni, chrysolepsis*), black, white, and blue oaks (*Q. Kelloggii, lobata, Douglasii*), buckeye (*Æsculus Californica*), buckthorn (*Frangula Californica*), toyon (*Heteromeles* or *Photinia arbutifolia*), manzanita (*Arctostaphylos manzanita*), madrona (*Arbutus Menziesii*), spiny chaparral (*Ceanothus integerrimus*), poison oak, or rather sumac (*Rhus diversiloba*). Among the herbaceous growth, the Yerba Santa (*Eriodictyon glutinosum*), several bunch grasses, the alfilerilla (*Erodium cicutarium*), and several native clovers were conspicuous.

It will be noted that the above list includes all the trees and shrubs mentioned before as characteristic of the foothills at large; so that so far as the vegetation can show it, the red soil here was fully representative of the higher class of land, on which alone the poison oak and toyon are found in the uplands.

The natural growth on the granite soil on the north slope and valley land adjacent the ditch, differed mainly in the less ample development of the trees and shrubs, and the scarcity or absence of the toyon, poison oak, and buckthorn; while the manzanita and chaparral, which prefer a sandy soil, are very finely developed.

Description and Analyses of the Soils of the Station Tract.

No. 111. Slate soil, from the south slope of the central hill, about halfway down. Depth taken, twelve inches. An orange-red loam, the lumps of which are easily crushed between the fingers when dry, and show considerable coarse sand; when wetted becomes only moderately adhesive, while its color darkens materially. Slate fragments are intermingled more

* These contour lines were surveyed, for the main tract, by a volunteer party of students (Messrs. C. E. Holmes and Chas. Claussen, of the class of 1889), under the direction of instructor Wm. G. Raymond of the University; for the rest of the tract, by the foreman, Mr. Geo. Hanssen, who has also furnished the drawing from which the plate was photographed for printing.

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or less all through, much of the sand being comminuted slate. The vegetation on this soil has been enumerated above; it is almost an epitome of the growths found in this portion of the foothill region.

No. 1114. Slate subsoil, from same locality as the above, and representing the depth of twelve to twenty-four inches. A loam of a glaringly orange-red tint, the lumps of which when dry can barely be crushed between the fingers; its color hardly changes in wetting, but it becomes quite adhesive when kneaded; like the soil it shows much coarse sand and some slate fragments. This material reaches here to depths of three to five feet, with increasing slate fragments. When vertically bedded slate is reached, which is generally much weathered, sometimes the line between it and the red subsoil is very indistinct; the latter is lighter colored near the contact line, from incomplete oxidation of the iron.

No. 1115. Granite soil, from the lower portion of the north slope of the central hill, toward the Amador ditch. A gray or fawn-colored sandy loam, full of granitic debris; dry lumps very readily crush between the fingers. On wetting the color darkens, showing the presence of humus, but on kneading only a very slight adhesiveness is developed. There is no obvious change below the line of twelve inches, to which depth the sample was taken. No obvious admixture of the slate soil from the hilltop is seen, but such may nevertheless have occurred to a slight extent. The vegetation on this soil is nearly the same in kind as on the slate soil, but the growth is less thrifty, and there is specially a smaller proportion of the toyon, buckeye, and poison oak.

No. 1116. Granite subsoil, taken to the depth of twelve to twenty-four inches. Very similar in color and texture to the surface soil, No. 1115, but increasingly composed of granitic debris or sand, becoming coarse as we descend, and finally passing at several feet depth into granitic gravel.

Because of the possible admixture of some slate soil to that of the hill slope on the station tract, it was thought best to take another sample for examination from the center of a granitic area, viz.:

No. 1117. Granite soil, from the Fleming tract, one half of a mile northeast from the station, and due west from the waterfall of a small creek passing over large granitic bowlders. A coarse, whitish-gray loam, with granitic gravel, manifestly derived from the underlying rock, that rapidly increases downwards, passing at from three to five feet into pure granitic debris overlying weathered rock. Dry lumps of the soil crumble under the fingers, showing a large proportion of very coarse sand; on wetting the color darkens perceptibly; kneading produces moderate plasticity, so far as the coarse particles permit. The vegetation on this soil, which is almost bare of herbaceous growth, is yellow pine, nut pine, blue and mountain (*Wislizenus*) oaks, manzanita, and chaparral; the latter quite large, while the tree growth is undersized.

For convenience of comparison, the red soil from the outer slate belt, inland from Ione, mentioned above, is inserted here:

No. 499. Red subsoil, from the foothills near Ione; sent by Mr. Thomas S. Crafts. The surface soil of the red land, to the depth of twelve to thirteen inches, is relatively light, so that dry lumps can be readily crushed between the fingers; an easily tilled loam. The subsoil, thirteen to twenty-five inches, is a good deal heavier, the lumps not to be crushed between the fingers, and quite adhesive when wetted. This subsoil varies in thickness: "From a depth ranging from about thirty-three to fifty-five inches, the red color changes to a yellowish tint; then, immediately upon the bedrock, which lies at variable depths, the color is bluish. The bedrock is slate, traversed by ledges of round, very heavy rock."

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	Slate—South Slope.		Granite—North Slope.			No. 784. Subsoil, Red Land. Ione, Amador Co.
	No. 1113. Soil, 12 inches.	No. 1114. Subsoil, 12 to 24 inches.	No. 1115. Soil, 12 inches.	No. 1116. Subsoil, 12 to 24 inches.	No. 1117. Soil, 10 inches. Fleming Tract.	
Coarse materials>0.5mm	19.20	7.86	40.00	40.00	50.00	4.50
Fine earth	80.80	92.14	60.00	60.00	50.00	95.50
Analysis of Fine Earth.						
Insoluble matter	49.96 } 64.92	40.93 } 62.16	62.44 } 73.95	64.57 } 79.75	77.11 } 82.51	48.98 } 67.68
Soluble silica	14.96	21.23	11.51	11.22	5.40	48.70
Potash (K_2O)	1.48	1.82	.53	.73	.35	.22
Soda (Na_2O)	.43	.43	.18	.17	.17	.10
Lime (CaO)	.60	1.37	.50	.39	.37	2.77
Magnesia (MgO)	2.21	2.28	.30	.62	.37	1.80
Br. ox. of manganese (Mn_3O_4)	.05	.05	.04	.04	.09	.09
Peroxide of iron (Fe_2O_3)	11.52	11.89	5.28	5.62	2.93	7.91
Alumina (Al_2O_3)	12.31	14.08	12.18	12.80	7.27	14.98
Phosphoric acid (P_2O_5)	.05	.07	.05	.06	.04	.04
Sulphuric acid (SO_3)	.02	.02	.01	.01	.02	.06
Carbonic acid (CO_2)						
Water and organic matter	6.63	5.62	7.28	5.83	6.09	4.11
Total	100.22	99.79	100.30	100.06	100.21	99.76
Humus	.54	.18	.48		.80	
Ash	.80	.33	.23		.31	
Sol. phos. acid	.03	.01	.02		.02	
Silica	.60	.19	.16		.26	
Hygroscopic moisture (absorbed at 15° C.)	5.74	6.59	5.93	5.62	3.27	7.90

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The prominent feature of the slate soil and the subsoil is the very large percentage of potash, wherein it competes with the richest soils of the San Joaquin Valley, although probably the potash is not in as available a form as the valley soils. The amount of lime, though not very high in the surface soil, is abundant in the subsoil. Direct determination shows .04 per cent to be in the form of carbonate.

The percentage of phosphoric acid, as usual in California upland soils, is not high, but very largely in the soluble form. The amount of humus is rather low, perhaps in consequence of the oxidizing influence of the very large amount of finely diffused iron oxide. The moisture absorption is that of the most desirable upland loams, increasing in the heavier subsoil.

The granite soil differs pointedly from the slate soil in its lower proportion of potash, albeit its percentages are quite satisfactory. But the supply of lime is notably lower than in the slate soil, pointing to a relatively lower degree of thriftiness from that cause. The total of phosphoric acid is just above the limit of deficiency, but, as in the slate soil, appears to be largely in the readily soluble form. Contrary to expectation in a soil so largely formed of granitic sand, the moisture absorption is quite satisfactory both in soil and subsoil, thus redeeming the land from the suspicion of droughtiness.

The purely granitic soil of the Fleming tract differs first of all in a very low percentage of potash, and still lower proportions of lime and phosphoric acid than are found in the granitic soils of the station; hence the predominance of pine over other growths. The almost entire absence of herbaceous growth from this soil is probably connected with its excessive openness and low moisture absorption, which together forbid the success of shallow-rooted plants; a condition which prevails in a striking degree in some of the granitic soils of the Sierra Madre, in Los Angeles County.

Altogether these analyses show good cause for the universal preference accorded to the slate soils over those of the granitic character throughout the foothills. They also show that, as elsewhere in the State, phosphate and nitrogenous fertilizers will be called for in this part of the foothill region long before the addition of potash will be needed; and that, while on the slate soil the use of lime would probably not pay, the same is not true of the granitic soils, which are manifestly benefited by the washings of the slate lands. The latter fact doubtless explains the greater abundance of lime in the granitic surface soil of the station, as compared with the subsoil, for, as a rule, the subsoil is of necessity richer in lime than its surface soil, as a result of the natural leaching process; a fact well exemplified in the slate soil and subsoil.

No. 784, the red subsoil from the outer slate belt, off Ione, differs remarkably from the subsoil of the station. It has over eight times less potash, and only a little over half as much phosphoric acid, but twice as much lime. Notwithstanding the latter advantage, it must be considered very much inferior to the red soil of the inner slate belt. While it would doubtless yield a few fair crops of grain, it would soon require the help of fertilizers; but it will certainly yield good returns in fruit. The lime apart, it is more nearly related to the soils of the "gravel plains."

Improvements Made on the Station Grounds.—The accompanying plat of the station tract will serve to illustrate the plan pursued in the improvements.

On the part of the *citizens* of Amador County, aided to some extent by subscriptions from adjacent ones, the following fundamental work has been done: A new road has been graded one and a half miles from the county road up to the station; the main tract (Boggs' land, twenty-one acres) was

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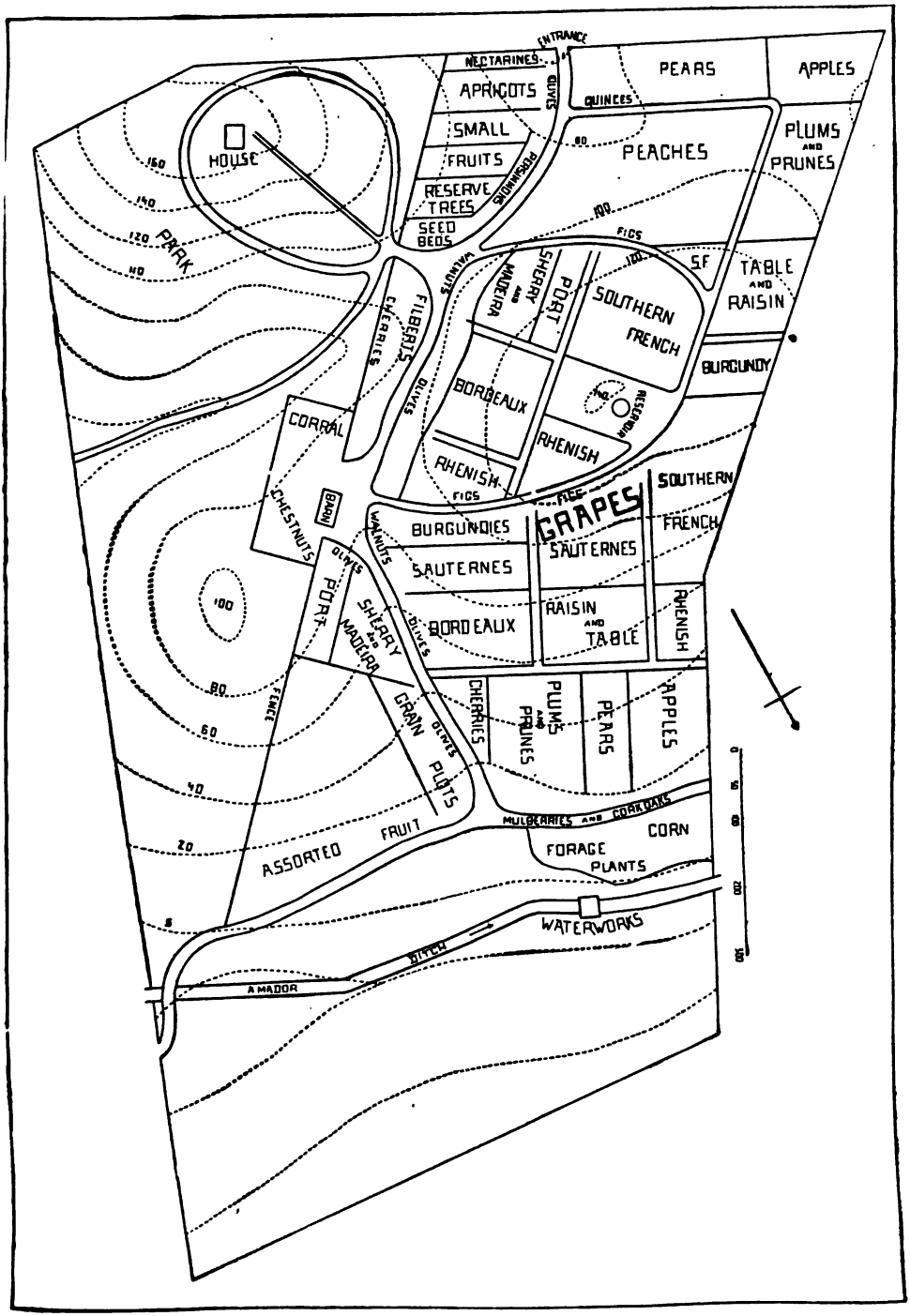

PLAT OF FOOTHILL EXPERIMENT STATION, AMADOR COUNTY.

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fenced with a board-and-wire fence, also grubbed and plowed; seven hundred feet of one and a half-inch water pipe laid to the summit of the central hill, one hundred and forty feet above the ditch level, to the irrigation reservoir, and inch pipe thence, eight hundred and twenty feet, to the residence hill, which is about twenty-two feet higher than the former. A frame two-story dwelling with eight rooms and an observatory turret for meteorological observations (according to plans furnished by the University) has been built on the latter hill, commanding a magnificent view among the mountains and over the Sacramento Valley, as far as Mount Diablo. A spacious barn, with wagon shed and tool house adjacent, has been built on convenient ground about halfway down the slope toward the ditch.

In addition to these liberal permanent improvements, the station was supplied with a good team of horses; and a thoroughbrace road wagon, needed to insure safe transportation of the station material to and from the towns of Jackson and Ione, is now being built; thus completing the fulfillment of the liberal promises originally made. In this respect the Foothill Station stands first among the three thus far established.

The improvements made at the expense of the *Station Fund* are the following:

The exterior tracts—the McKay tract of six and one half acres, lying across the ditch, and the "Italian's tract" of nearly the same area, eastward of the main tract, and on part of which the dwelling is situated—have been fenced with a board-and-wire fence similar to that surrounding the main tract, and about seven acres have been cleared in addition to the twenty-one acres of the latter, in order both to increase the area, and to obtain control of a more purely granitic soil, uninfluenced by the washings of the slate hills.

At the main entrance, on the road connecting with the county road to Jackson, has been placed an "Aylward Automatic" gate, easily opened without dismounting from horse or vehicle.

A substantial bridge of sawn timber has replaced the log-and-pole bridge that at first was made to span the Amador ditch, so that wagons can cross with safety from the main tract to the McKay donation.

The laying-out of the roads, as shown in the ground plan, has necessitated a good deal of surveying and grading; some of the side-hill roads having to be sustained by rough stone walls, while others, to prevent washing (which is especially bad on the northern or granitic slope), as well as to make the curves permanent, have been edged with flat stones set on edge, giving them quite an ornamental appearance. Considerable work, including blasting, was also involved in cutting a convenient and permanent road up to the residence hill, with such grade as to permit ordinary vehicles to ascend with some ease to the house front. Around the latter the ground has been cleared with due regard to leaving the natural growth of trees and shrubs—among the latter some magnificent manzanita bushes—to represent the native vegetation of the region, tastefully disposed so far as the inroads formerly made upon them would permit.

In conformity with the wish of the citizens contributing to the station equipment, the dwelling house was placed on the highest point within the tract, so as to afford as extended a view as possible. While this object has been attained so as to render the station one of the finest accessible points of view in the foothills, the dwelling is thus much exposed to the violence of storms, and the lightness of construction that would have caused little or no inconvenience in the valley or under the lee of the hill, has proved somewhat troublesome in its effects, and has necessitated a number of repairs and changes. At the same time, the additional eleva-

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tion above the main reservoir has complicated the question of water supply for domestic use; for the raising of which special appliances (pump or ram) will have to be provided, and are now under consideration. The house, as originally built, had a foundation of wooden planks only, and these being of easily decaying pine, it was thought advisable to supplement them with piers of stone, the material for which was taken from immediately around the house. The very exposed location of the dwelling, and its light construction, rendered this precaution quite essential. In addition, to increase its stiffness and to prevent leakage from driving rains, to the injury of the ceiling below, it was thought best to lay a floor of planks in the attic. The front porch has also been strengthened by braces, so as to resist better the heavy strain brought to bear on it by storms from the south. The shrinkage, consequent upon the extraordinary changes in the moisture-condition of the air that so frequently occur here, will render repairs, in tightening joints of windows, doors, etc., necessary for some years to come.

The barn has also been additionally supported, being in part built upon "made" ground, which yielded under the influence of the winter rains; it has been tightened with battens on the outside, and a partition, forming a tool house and carpenter shop, has been put inside. A corral for the horses and a lean-to for additional storage has also been lately added.

For the accommodation of the numerous visitors that frequent the station, a number of benches and other seats have been placed at various points in the grounds.

An outhouse for wood, poultry, etc., has been built a short distance from the dwelling, which affords no space for storage.

The *water supply* of the station has involved somewhat complex arrangements and a not inconsiderable expense, and it might be thought that it would have been preferable to locate it at some point below the ditch; but of the numerous localities examined, none offered the complete exemption from local influences and currents, nor the representation of soil varieties, that has been attained in the present location; and it is believed that these important advantages have been cheaply purchased by the outlay incurred for waterworks.

As the first measure, a reservoir of twenty-five thousand gallons capacity has been excavated on the central hill, mostly into the slate bedrock, to be lined with cement, or with brick and cement where necessary. To raise the necessary water for irrigation to this reservoir was a question of greater difficulty than was at first supposed, for although the total fall of the Amador ditch within the limits of the station grounds is nearly eight feet, experience has shown that the nature of the banks is such that only five feet can ordinarily be utilized. After considering the several alternatives for motive powers—breast wheel, shovel wheel, and turbine—the latter was thought preferable, all things considered. By permission of the ditch company a wooden dam was thrown across at the lowest point affording a hold in the granite rock, through which the channel has been cut at this point. A double cross of heavy redwood timbers was cemented into sockets excavated in the granite, and the dam made tight with redwood lagging (one and one half-inch), on which are placed three gates—one in the bed of the ditch and one for waste when the turbine is in use. The twenty-inch iron turbine is placed in a penstock of heavy redwood boards, and is provided with a suction pipe; so that of the five feet of head actually available, about half and half is pressure and suction. The dam was originally constructed with a view to a head of seven feet, but it was subsequently found that to use it to this extent endangered the banks of

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the ditch above, much of which are "made" ground more or less inhabited by gophers; hence the reduction to five feet, which involved a lowering of the penstock and turbine.

The turbine is coupled by means of a belt to a horizontal pump with four-inch cylinder and twenty-one-inch stroke.

The one and one half-inch pipe, seven hundred and fifty feet in length, which had been laid from the ditch to the reservoir by the citizens' committee, proves too small to permit of pumping the water to a greater height than the reservoir, without putting undue strain upon the machinery. It is found that with the diminished head, one thousand two hundred gallons per hour can be thrown into the reservoir, which can be filled completely in the course of twenty-one hours; thus affording sufficient capacity for all irrigation likely to be needed. It is, however, intended to replace the one and one half-inch pipe by a larger one, and use the former for distribution purposes. It is, nevertheless, probable that even with double the capacity of the main pipe, it will not be feasible, in view of the small head available, to pump water up to the dwelling. It is therefore proposed to raise the needful household supply from the level of the reservoir to the house (about twenty-five feet) either by means of a pump at the house, or by a ram to be run from the main reservoir, returning the waste water to the ditch when not required for irrigation.

Need of Irrigation.—The question of the extent to which irrigation is necessary or desirable in the foothills has been much discussed, and experimental investigation will be one of the most important functions of the Foothill Station. From observations made within the last two years, my impression is that neither of the extreme views will be found justified; and that while in the case of deep soils of great intrinsic fertility irrigation may not repay its cost, yet in most cases the command of irrigation water is of very great importance to foothill farmers, and will be found highly profitable in numerous cases, where without it the crops grown would be inferior both in quantity and quality. While over-irrigation will in the foothills, as elsewhere, produce tasteless, squashy fruit, of poor keeping and shipping qualities, yet *judicious* irrigation (in the majority of cases in actual practice) will undoubtedly increase the size and flavor of the fruit without injury to its shipping qualities.

NOTES ON CULTURE EXPERIMENTS AT THE FOOTHILL STATION.

By W. G. Klee, Inspector of Stations.

Orchard.

The nature of the land being that of strongly rolling hills, it has been the aim to give the various varieties of fruit, as well as other crops, the benefit of different exposures. Thus, for example, the apples have been given northeasterly exposure, and peaches southeasterly exposure. Whenever possible, the various kinds of fruit have been planted both on the granitic and the slate formation, to test their adaptability to these, the two great prevailing soils of the foothill region.

Apples.—This region being regarded, and with reason, as well suited for the production of apples of good keeping qualities, some eighty-five of the best varieties were planted, and the collection will be largely increased this year. The growth during the early part of the season of all the apples was uniformly good; but severe loss was met with during the latter part of the year from various causes; the excessively dry and hot season increasing

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the injury caused by deer and other animals, and preparing the way for the work of the flat-headed appleborer (*Chrysobothris femorata*). Experience shows that young trees (especially apples) in this region require very careful shading of the trunk; neglect of this resulting in burning of the bark and an invitation to the borer. The growth of the apples on the slate formation, as a general thing, is better than on the granite. Low training of all trees is a necessity in this region and soon gives the trees natural protection from sunburn, provided it is carried out logically by building the frame-work of the tree from below on the main branches and not allowing these to become bare.

Pears.—All the best varieties of pears to be obtained in the State have been planted. The growth, as a general thing, has been fair, the number of trees lost being comparatively small. The Japanese seedlings have done very well.

Plums and Prunes.—In the main the same varieties were planted at this station as at the others. The majority of the plums and prunes are on the Myrobalan stock, some varieties being duplicated on peach, and some on apricot. From Berkeley an assortment of dormant buds on Myrobalan was sent. Of these a good many were lost. Few of the prunes were planted on the granitic soil; and it is yet too early to note any difference in the growth on the two kinds of soil, or in the various stocks. Here, as at Paso Robles, the Japanese varieties have done well. On the whole, the growth of the plum has been very moderate; but few outside of dormant buds were lost.

Apricots.—Some twenty-five varieties of apricots were planted, the majority being represented both on the Myrobalan plum stock and on apricot. The former were dormant buds, of which quite a number were lost. The growth of a few trees in nursery, however, indicates that the soil has nothing to do with this failure, the growth of the buds which survived being very good. Of the apricots on apricot root the growth has been moderate, with loss of some varieties.

Peaches.—A large collection of all the best varieties obtainable in the State has been planted. Of those on peach root very few have been lost, and the growth for a dry season must be considered good. Many trees, however, show much exudation of gum at the root, a trouble from which stone fruit trees in the foothills suffer greatly. So far the peaches on Myrobalan roots have suffered less; but, being all dormant buds, it is premature to draw any conclusion. The gum trouble is more pronounced on the granitic soil than on the slate, but sufficiently serious to be worthy of thorough investigation as to the true cause and experimentation as to preventives. This line of investigation will be commenced this year. On the supposition that the tap-root of seedlings by going deeper is more liable to suffer from excess of moisture, liable to occur in shallow soil, rooted cuttings of plum stocks will be planted.

Nectarines.—These behave like the peaches.

Almonds.—All varieties have grown exceedingly well, and the list will be increased with all the promising California seedling varieties possible to obtain. As to their profitable production in this section, very few data are at hand, and their probable success rests very much upon the power the flowers of the different varieties have to resist frost, which is liable to occur during the early blooming of the almond. This power of enduring quite sharp frosts is a point claimed for many California seedlings, not sufficiently tried, however.

Cherries.—The varieties planted of this fruit embrace all the principal sorts cultivated in the State, and many new ones. As a general thing

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they have done well, the growth being very good, and the loss exceedingly small. Some of the best soil was selected for them.

Quinces.—Some seven varieties of this fruit were planted. The growth of all has been good. They were planted on slate formation only.

Figs.—As to the general adaptation of the fig to the climate of the foothills there is no question. But the special points still to be ascertained are many. It is very important, for instance, to determine which are the best varieties for drying, also whether irrigation or non-irrigation will yield the best results. In planting a large collection, we have in view not alone to decide these questions, but also that of nomenclature, which is in a very confused condition in the State. The forty correctly named varieties are planted so that they extend upon both the principal soils, being set as a border to an avenue, which encircles the reservoir hill. The growth of most of the varieties has been good.

Walnuts and Pecans.—The growth of these trees has been uniformly good; and their foliage has suffered but little from the attack of mites, a circumstance worth recording, as the season has been especially favorable to the development of these insects. The wood has also ripened well, fitting it to withstand any degree of cold liable to occur. The deepest and best soil has been given to these trees.

Chestnuts.—Several kinds were planted, some of which died. The growth of the surviving ones was moderate.

Oranges.—The budded varieties planted have been making fair growth, while the sour seedlings have established themselves very well, very few being lost. These trees suffered considerably until water for irrigation was obtained. The place given to the oranges is a spot believed to have the mildest temperature in winter. The soil is of average depth.

Olives.—Believing that the foothills of the Sierra Nevada have advantages for the olive, both in soil and climate, over many other sections, particularly because of the inability of the black scale (*Lecanium oleæ*) to gain a foothold here, the olive has been given a full representation, both in number of varieties and number of trees. An avenue running through the whole station grounds, taking in the different shades of soil, has been lined with all the varieties obtainable. So far the growth has been the best on the slate soil, all varieties being represented on both; but the growth has been good on all soils. For vigor the Nevadillo blanco, here as everywhere else, excels any other.

Japanese Persimmons.—The trees planted were all Japanese importations of the current year. The growth is fair.

Miscellaneous Trees.

Mulberries.—The growth of the different varieties has been uniformly good—better and stronger than any other deciduous tree planted.

Camphor Tree.—The tree shows fair growth, and resists the hot sun well.

The *Kai Apple* (*Aberia Caffra*) seems especially at home, and would most likely prove a valuable hedge plant. Its resistance to cold is still untried.

Bamboos.—The Japanese variety (Metake), sent from Berkeley, is looking well, and will prove hardy. None of the imported roots of Japanese Giant bamboo succeeded. The Chinese variety, originally imported from Choofoo to Berkeley, is also perfectly at home. Both kinds have received several irrigations.

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Vineyard.

In planting the vineyard at this station, we have aimed to take advantage of the contour of the ground, by placing varieties demanding a greater heat on the warmest slopes, and those better adapted to a cooler climate on northeast slopes. Thus, for instance, Riesling and Bordeaux varieties have been planted on land with a northeasterly aspect, while sherry and port varieties have been planted where they would receive the full benefit of the sun. This, together with the duplication on different soils, has caused the vineyard to be a little scattered. A number of varieties of wild vines, interesting as resistant stocks, have been rooted in nursery, and will be planted in vineyard this season. Of eighty-six varieties planted, forty were rooted vines. Of seven of these varieties all vines grew, while the remainder show a failure in the following proportion: Of eleven varieties, less than 3 per cent; sixteen varieties, less than 10 per cent; six varieties, less than 20 per cent.

The other forty-six varieties were planted with cuttings, the loss of which varies from 20 to 70 per cent, the average being about 50 per cent. It should be noted that these vines were practically unirrigated, the water for this purpose not being available before the middle of July. None of the vines have grown very much, but have merely established themselves.

Small Fruits.

Irrigation having been impossible early in the season, this class of fruits, very difficult to raise without water, suffered. The raspberries were worst affected. Blackberries and strawberries were lost in large numbers, while gooseberries, and especially currants, did reasonably well, 90 per cent of each growing and making a fair showing. Water was supplied to them about the middle of July.

Forage Plants.

The seeds of all the grasses and leguminous forage plants, planted last spring, remained dormant until the fall rains of 1889, when many of them appeared. Of those starting at this time, and making a fine growth during the succeeding month, the *Bromus inermis*, *Bromus Schraderi*, and *Festuca elatior* have made the best showing, Schrader's brome grass especially so.

The various *sorghums* planted in the spring did only tolerably well, the growth being smaller than the same variety planted in Berkeley. *Teosinte*, or *Reana luxurians*, does not reach any size, and behaves much as it does in Berkeley, forming only a low tuft, although very leafy. It shows no tendency to bear seed.

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THE SOUTHERN COAST RANGE STATION.

Location: Two miles north-northeast from Paso Robles, San Luis Obispo County.

The Coast Range Region at Large.—The Coast Range region forms a belt varying in width from forty to sixty miles, lying between the Great Valley of California and the seacoast. It is traversed by numerous more or less disconnected ranges, mostly trending parallel to, or at a small angle with, the coast line. From Mendocino County, inclusive, southward to the northern end of the San Bernardino Range, few points or crests exceed the height of four thousand feet, and most of the higher ranges remain between three thousand and three thousand five hundred feet. Many of these are very rugged and barren, and largely treeless; of the lower ranges, from two thousand to two thousand five hundred feet, many are rounded in outline, largely forest-clad, deeply covered with soil, and in the moister portion of the region susceptible of cultivation to the summits. The higher portions are thus far occupied as grazing grounds only, the bulk of the cultivated lands lying in the valleys or on the lower slopes and hill lands.

In conformity to the mountain ranges, the larger valleys also mostly trend more or less parallel to the coast; while those of smaller streams, descending from the outer slope of the Coast Ranges to the sea, generally open more nearly at right angles, thus giving free access to the coast winds. The latter condition determines very great differences in local and even regional climates; and as the California coast extends through nine and a half degrees of latitude (coextensive with the Atlantic Coast from Boston to Savannah, Georgia), with a rainfall ranging from eighty inches down to ten, it may readily be imagined that no *one* culture station can even approximately represent the Coast Range region *as a whole*. The Central Station at Berkeley, although geographically nearly central, north and south, really has an exceptional climate, dominated by the cool currents and summer fogs that enter through the Golden Gate, and thus represents only the immediate seaward slope of the central portion of the coast for a few miles inland. It thus becomes necessary to make a choice of such portion of the extensive region as seems to stand most in need of an experiment station for its immediate future, thus benefiting the largest number of agriculturists.

It has been thought that these conditions would be best fulfilled by the establishment of a culture sub-station at some point in the largest valley of the southern Coast Range—that of the Salinas River—representing a very large area of agricultural land, just being opened by the extension of the Southern Pacific Railroad, and but little tried as to its productive capabilities. As the needful offers of land and money for station buildings were made from the upper Salinas Valley, two personal visits to that region were made for the purpose of exploration and final location. The following description of the region, for the special benefit of which the "Southern Coast Range Station" was established, is based partly upon these visits, partly upon data obtained in connection with the census of 1880, and heretofore published in the reports of that work. (See Vol. 6, monograph on "The Physical and Agricultural Features of California.")

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The Southern Coast Range region, as here understood (*i. e.*, exclusive of the "bay counties" north of the Bay of Monterey), embraces the counties of Monterey, San Benito, San Luis Obispo, Santa Barbara, and Ventura, with the extreme western portions of Stanislaus, Merced, Fresno, Tulare, and Kern that lie westward of the Great Valley.

The main mountain ranges of this region are, in the northern portion, and bordering the San Joaquin Valley on the west, the southern continuation of the Mount Diablo Range, which loses its identity in the lower, spreading ridges of southern San Benito; next to westward the (mostly treeless) Gabilan Range, flanking the Salinas Valley on the east; while the Santa Lucia Range and its offshoots lie between that valley and the coast, with a width of about thirty miles; high hills reaching to or within a short distance of the coast, the small coastward streams, being usually accompanied by valleys of greater or less width. The coast mountains are in places heavily timbered on their lower slopes and in the cañons with Monterey pine (*P. insignis*), Monterey cypress (*C. macrocarpa*), live oaks (*Q. agrifolia, Wislizeni*), blue, white, and black oaks (*Q. Douglasii, lobata, Kelloggii*), the California buckeye, laurel, etc. Farther southward, toward the junction of the Coast Range with the Sierra Nevada, we find a broad and extensive region of high mountains—the Sierra San Rafael—in the eastern part of Santa Barbara and northern part of Ventura Counties, merging on the southeast into the San Bernardino Range. Near the coast, in the southern part of Santa Barbara County, there is a small but rugged range, the Sierra Santa Inez, from two thousand to three thousand feet in height, trending nearly due east, parallel to the coast below Point Concepcion.

Climate.—The climate of the coastward slope of the outer range, and of the valleys opening directly upon the coast, is so different from that of the region to eastward of the Santa Lucia divide that a special station only could represent it. The direct influx of the trade winds imparts a moisture to the air and insures it a relatively steady temperate thermometric record, corresponding to the "bay climate" of the San Francisco region, with a rainfall but little lower; the average of fourteen years' observations at San Luis Obispo being twenty-one inches, against about twenty-four at San Francisco. Passing the crest of the Coast Range to eastward, we are at once transported to the dry atmosphere of the interior; but owing to altitude, the rainfall is greater (about fourteen inches against six) and the average temperature lower than in adjacent portions of the Great Valley. Hence here, as on the coastward slope, irrigation is not necessary for general field crops, although the command of irrigation water is always desirable.

Agriculture.—Until recently the western slope of the immediate Coast Ranges, and the valleys pertaining thereto, have been the chief agricultural districts of the region, the interior being given up to stock ranches. Carmel Valley, in Monterey County; the San Luis, Arroyo Grande, Santa Maria, and other minor valleys of San Luis Obispo County; the Santa Maria, Todos Santos, and Santa Inez Valleys, together with coast "vegas" of Santa Barbara and Carpenteria, in Santa Barbara County; finally the lower valley of the Santa Clara River, and the fertile coast plain of Saticoy and San Buenaventura, in Ventura County, have long been noted for their choice and abundant products, both of the field, dairy, and orchard, and have fed a heavy coastwise trade, to which the country beyond the crest of the Coast Range contributed only cattle, horses, and wool. The opening of the railroad to the upper Salinas Valley bids fair to change both the

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nature and the quantity of the products of the interior country, and to place it on a level with the coastward slope as an agricultural region.

Rocks and Soils of the Region.—The greater part of the several ranges just mentioned is formed of rocks of the tertiary period, consisting of more or less calcareous sandstones, claystones, and clays; sometimes in their original, horizontally stratified condition, but oftener folded, faulted, and sometimes intricately contorted, and then often associated with various crystalline rocks, often granitic, but along the immediate Coast Range very generally serpentinous or talcose.

Of course the soils vary in accordance with the rocks from which they have been formed; those derived from the tertiary clays and soft claystones are predominantly "adobe" or heavy clay soils, mostly brown or blackish, and very commonly overlie the very rocks from which they are derived ("colluvial" and "sedentary"); they are found on the higher lands rather than in valleys, and usually appear on the "divides" and ridge lands generally, as well as in the higher valleys. On the coast slope the valley soils, owing to the more complex nature of the rocks, are predominantly loams, more or less heavy or sandy, sometimes ferruginous. In the interior region, the valley and mesa soils are almost throughout quite light, often gravelly. On the slope toward the San Joaquin Valley, the sand is derived from the tertiary strata forming the hills themselves, and is largely quartzose; while in the Salinas Valley, the soil is predominantly composed of *granitic* debris, derived from the granitic region about the heads of the river, being the northwestern end of the granitic mass that forms the San Rafael and San Bernardino Ranges. This granite weathers very rapidly, and has yielded prodigious masses of granitic sand and gravel, which have filled to great depths not only the plains of the upper Salinas, but form a very large ingredient of the valley lands down to the Bay of Monterey, and are doubtless largely concerned in the high productiveness for which that valley is noted in the portions that have been longer under cultivation, in northern Monterey.

It is not intended in this report to give a detailed description of the *whole* of the southern Coast Range region, but mainly of that portion represented by the station that has been established in the upper Salinas Valley. It is therefore to the latter that the details hereafter given mainly refer.

THE SALINAS VALLEY.—The Salinas Valley divides naturally into an "upper" and "lower" portion, differing considerably in climatic as well as in soil conditions.

The *lower valley* is a club-shaped area, widest at its lower end, extending from Monterey Bay southeastward about ninety miles, with a width of from twelve to eight miles for the first fifty miles, when (about San Ardo Station) it rapidly narrows, thereafter rarely exceeding one mile in width and frequently narrowing so that the broad, sandy bed of the river occupies the entire valley, while at the same time it rapidly ascends toward the point where, near the old Mission San Miguel, at an elevation of six hundred and sixteen feet, the plains of the upper valley begin. The narrow portion is not, however, a cañon, but is bordered by sloping hills rising rather gradually toward the crests of the ranges. The wider portion of the lower valley presents a terraced and almost treeless plain, with but a few live oaks, and sycamore, willow, and cottonwood along the river itself. The alluvial bottom lands here are from a quarter to half a mile wide, their soils rather sandy, and are bordered by a bench or second bottom of adobe soils, from one to two and a half miles wide. The river flows mostly on the west side of the valley, a region of mesa lands lying between it and

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the Santa Lucia Range, still farther to westward. On the eastern side of the valley the adobe bench lands are again bordered by a sharply defined terrace ten to twelve feet higher, rising gently toward the Gabilan Range. The surface of this terrace is rather rolling, and its soils are coarse, red, and gravelly, affording excellent farming lands. Until within the last few years the valley above Salinas City was occupied chiefly as a stock range, it being reported that the high winds prevailing through the year rendered it unsuitable for farming purposes. Like many of the tales made current by the stockmen, *this* has vanished before a more impartial view of the situation; and the lower valley is being rapidly settled up along the railroad. Its rainfall is rather low, despite its full exposure to the ocean winds, being at Soledad only between eight and ten inches. Irrigation from the river is, however, perfectly practicable, if found necessary. Scarcely any affluents enter this part of the valley from the west side, the waters of the Santa Lucia Range all flowing to seaward. From the Gabilan Range quite a number of streams, but mostly of very small volume and intermittent flow, come in.

The Upper Salinas Valley may be said to begin where the larger affluents come in from both sides; the Nacimiento being the first to enter, at Bradley Station, from the west; and a short distance above, the Estrella and Huerhuero from the east. The Nacimiento has only a narrow valley and has in general the character of a mountain stream, as is the case with all the western affluents above; while the Estrella, Huerhuero, and their tributaries share the peculiarity of wide, sandy beds, in which the water is for long stretches visible only in time of flood, although easily reached and quite abundant in the sand with which their channels are filled. Even in the main Salinas this characteristic exists to such extent that considerable caution is required in fording at unknown points, although running water usually exists in it above the sand, throughout the season.

The table below gives in summary form the most important *meteorological* data thus far available for the upper Salinas Valley. It should be borne in mind that, as it happens, the years included within these observations were, throughout that portion of the State north of the San Bernardino Range, seasons of exceptionally light rainfall; while the reverse was true of the country lying to southward. Probably the average drawn by taking into calculation the extraordinarily heavy rainfall of 1889–90 would more nearly represent the true general average of the upper valley:

Table showing the Rainfall and Average and Extreme Temperature for Summer and Winter in the Upper Salinas Valley. From observations of two years from November, 1886, to December, 1888, inclusive.

Location.	Elevation—Feet.	Rainfall—Inches.	Winter Temperature.				Summer Temperature.			
			Average Maximum.	Average Minimum.	Extreme Minimum.	Average Mean	Average Maximum.	Average Minimum.	Extreme Maximum.	Average Mean
San Miguel	616	10.0	72.3	23.5	17.0	47 6	106.3	51.0	108.0	71.2
Templeton	-----	14.2	76.5	23.0	13.0	48.2	104.2	51.3	108.0	71.6
Paso Robles	-----	11.9	70.8	19.8	15.0	45.9	101.6	47.6	103.0	70.7

It is of some interest to compare these data with the corresponding ones for the Tulare Valley, nearly in the same latitudes. It is thus shown that on

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the whole the upper Salinas Valley climate is materially cooler, as might be expected from its greater elevation and proximity to the coast. The extreme winter minima (so important in determining cultural possibilities) are about 4 degrees lower than the average of the three Tulare Valley stations (Fresno, Tulare City, and Bakersfield); on the other hand, the winter maxima average about 3 degrees higher. The winter means differ about 2 degrees in favor of the Great Valley. As to the summer, the extreme maxima are from 5 to 7 degrees lower in the Salinas region, the minima fully 10 degrees, the average mean for the summer nearly 12 degrees. Add to this a rainfall more than twice as great on an average, and (probably) a higher average of moisture in the air, and it becomes easily intelligible how the upper Salinas Valley can, for ordinary crops at least, do without irrigation; and how persons from the valley, as well as from the coast slopes, may be benefited by the climatic change to the Salinas plateau.

Agriculture.—The main *crop* of the upper valley, since pasturage has been largely superseded by agriculture, has thus far been grain; the usual first resort in a new region. But the obvious fact that the light, deep granitic soils of the Estrella Plains are not best adapted to grain culture, even if such use were otherwise profitable, early led to experiments in fruit growing; with highly encouraging results when it is considered that the pruning of the trees to high standards placed them under the grievous disadvantage of being liable to sunburn on the south and southwest sides. Some of the older plantings have been badly disfigured and injured from this cause; and yet the results have been both good in quality and profitable in the local markets. There can be no doubt that with the low pruning practiced elsewhere in the State, and here especially indicated by the shape of the natural tree growth (which is low and spreading), all kinds of deciduous fruits, the olive, the vine, and perhaps the citrus fruits as well, will find a congenial home here. Some experience leads to the belief that a late crop of Bartlett pears will be likely to prove particularly remunerative. In the bottom lands of the Salinas and Huerhuero, alfalfa, maize, sorghum, and other forage crops have given excellent results without irrigation.

Hydrographic Features of the Upper Salinas Valley.—The main river keeps along the foothills of the Santa Lucia Range, on the western border of the upper valley, and its extreme heads lie in a broken region to eastward of the Santa Margarita Ranch; far short of the heads of the Estrella, which reach at least twenty miles farther to the southwest, and should, according to geographical usage, constitute it the main river. Its inferior water volume has probably prevented the popular acceptance of this view. Between the heads of the two streams there intervenes a chiefly granitic mountain mass, which may be considered as the most northerly spur of the Sierra San Rafael. Emerging from its narrow valley above La Panza, San Juan Creek, the main head of the Estrella, still keeps to eastward along the foot of a hilly country until it is joined by Cholame Creek, which flows from the north around the most southerly spur of the Gabilan Range, here designated as the Cholame; then after flowing due west for eight miles, it continues northwesterly along the western foot of the Gabilan, joining the main Salinas near San Miguel.

Between the course of the Salinas and that of the Estrella, just debed, scrilies the main body of the "Upper Valley," which from Paso Robles across to the Cholame Range is about ten miles wide, and from San Miguel to the foot of the granitic hills to southward, about eighteen miles. It is in the main a gently rolling plain—"Estrella Plain"—rising

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to about one thousand feet altitude in its higher portions, and into which several minor watercourses, among which the Huerhuero is the largest and best known, have cut narrow valleys, often little exceeding the width of the rambling, sandy channel itself. From these the rise to the level of the plain or mesa is usually by several well defined terraces or benches, showing clearly that at previous periods the water level was much higher, and has been lowered by successive breaks in the obstruction intervening between the upper and lower valleys. In fact, it is obvious that at one time the entire upper valley was practically a lake, during the existence of which the deep granitic sand, that forms the main body of the uplands, was brought from above and deposited in the bed previously scooped out in the deposits of (tertiary) clays, marls, and claystones, that even now form the bordering ridge on the east bank of the main Salinas, and which jut out here and there into the plain itself at the present time. But, from the existence of high bluff banks of clay and loam along the streams, underlying the granitic upland soil, it also appears that before the coming down of the flood of granitic sand there was a time when clayey and fine, sandy materials were chiefly brought down into the lake bed.

In the absence of a close examination of the country above, it is not possible to designate more precisely the sources of these several materials or the cause of the apparently sudden and complete change in the nature of the soils formed. What has been said will suffice for an understanding of the manner in which the several kinds of land are disposed with respect to each other. A cross-section of the country from Templeton and Paso Robles, on the Salinas, to the Huerhuero and beyond will illustrate this.

Templeton is situated on the west bank of the Salinas River, on a bench about thirty feet above the flood plain; this bench extends about five miles to westward, to the foot of the Coast Range, and has a gravelly loam soil, which, under good cultivation, is very productive. Like most of the upper valley, it bears a sparse but vigorous growth of white and blue oaks.

Crossing the river, we find a bluff about sixty feet high, composed below of horizontal beds of partly siliceous, partly calcareous claystone, with some marl beds containing oyster and other marine shells to show their origin; while the higher part of the bluff is composed of a puddingstone formed of white siliceous (hornstone) pebbles, similar to those that are abundantly found on the surface of the gravelly areas, on the Salinas slope, while they are wanting on the Huerhuero side. The soils become heavier as we ascend the divide, and on the latter a well defined brown adobe prevails, sometimes underlaid by a calcareous hardpan. Descending on the east slope toward the Huerhuero, we find on the higher portion of the slope the coarse, sandy, granitic soil overlying the adobe; lower down, the immediate slopes of the creeks and of the Huerhuero itself are formed of a rather sandy, yellowish loam, underlaid by gravel, and this sometimes by heavy, blue clay, near the water level. Trees and shrubs seem to grow on this loam wherever it is exposed, without reference to its depth below the surface of the stratum.

The town of *Paso Robles* is located on a bench very like that at Templeton, but of much less extent east and west; the town fronting on the river and leaning against the Coast Range in the rear, although with abundant room to extend up and down the river. Here also the same gravelly surface, underlaid by a substantial yellowish loam, is seen, and in the river itself we observe the same strata as near Templeton and above, viz.: whitish hornstone, overlaid by puddingstone made of similar materials, and whitish clays. Ascending the bluff on the east side, we see the gravelly slopes with more or less of dark-colored clay that has been washed

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down from above, and then find ourselves in an undulating country—bunch-grass land dotted with oaks—in which the soil is largely adobe nearest the river, but alternates with sandy streaks as we progress eastward, until within a mile from the river we reach the regular granitic, sandy lands, with here and there hillocks of black or brown adobe land projecting above it. These grow fewer to eastward and are finally submerged altogether in the sandy mesa, which then continues to the Huerhuero, and beyond to the Estrella.

These hillocks are noteworthy for the luxuriance of their vegetation, and its freshness at the time when the sandy lands are already assuming their brown summer garb. The cause of this difference will be discussed below, in connection with the soils of the station.

Crossing the Huerhuero to eastward, we find the granitic sand filling the bed and forming terraces on the opposite side, the soils of which appear to be the same all the way to the top level of the mesa; nor, in digging down in the latter, is any material change observed for six or eight feet; nor does any important change seem to occur all the way from the Huerhuero to the Estrella, except that the tree growth, which, between the former stream and the Salinas is quite abundant, becomes thinner as the Estrella is approached. This is ascribed by the inhabitants to a diminishing rainfall as we go east, the immediate neighborhood of that stream being credited with less than two thirds of the rainfall observed near the Salinas. The Cholame Range, beyond the Estrella, is covered with a sparse growth of pine on its higher portions.

The tree growth of the entire region consists of scattered oaks or groups of oaks, thickly hung with lichen (*Evernia*), giving it a park-like and very attractive appearance. The ground is usually dotted with bunch grasses of various kinds, with much alfilerilla and a great variety of flowers, and affords fine pasture. The oaks are almost exclusively of two kinds: the white oak on the low land and in the gulches; the blue oak, magnificently developed, on the mesa land, whether sandy or adobe. The average density of the tree growth was well gauged on the station grounds, where about one hundred trees were grubbed out of twenty acres, or an average of five trees per acre.

Other Features of the Upper Valley Region.—As outlying portions of the upper valley, three regions require mention. One is the *Cholame Valley*, drained by the two creeks ("Big" and "Little") of the same name; the former heading about thirty-six miles to *northward* of its junction with the Estrella, on the eastern slope of the Gabilan; the latter (a much smaller stream) on the western slope of the border range of the San Joaquin Valley. These valleys comprise considerable bodies of excellent agricultural land, also in past times reported to be good for stock grazing only; but being now rapidly settled, with excellent results without irrigation. The soils are reported as being yellowish loams, without much gravel; therefore entirely different from the mesa soils of the Estrella Plain, but probably of the same character as the loam bluffs on the borders of the Huerhuero and its tributaries. Probably the Cholame country was too high to be overrun by the flood that carried down the granitic sand soils.

The other outlying area to be mentioned is the *Carisa Plain*, a valley or basin averaging about three hundred feet elevation above the Estrella Plain, and of considerable extent—said to be about ten miles wide by sixty in length. It lies to eastward across a low ridge from the upper San Juan Valley, and is bounded on the east by the western slope of the border range of the San Joaquin Valley. The drainage of this basin would naturally lie toward the north, and form an eastern affluent of the San Juan;

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but it seems to have no natural drainage whatever, but instead, in its middle portion, a succession of salt marshes and lakes, five miles in length, having water only during the rainy season. It is stated that the prevailing soil of the Carisa Plain is a deep, friable loam, and on the rolling land, and part of the plain, a heavy, gray adobe, of course largely infested with alkali; but that, while no drinkable water exists on the surface, it forms a good sheep pasture in spring, the animals finding the necessary moisture in the succulent herbage. In summer it was said to be uninhabitable for lack of water, but this statement is denied by the large ranchers and settlers that have of late established themselves there.

It would seem amply worth while to make a close examination of this region to determine more accurately the nature of its soil, and especially the possibility of obtaining water from artesian wells. Its altitude is not so great as to render this improbable, considering that it lies considerably below the crests of several neighboring ranges.

The eastern slope of the Santa Lucia, or outer Coast Range, from which flow a number of lively permanent streams, such as the San Marcos, Paso Robles, and Atascadero Creeks, has along these streams some fine foothill country and valley lands; not in large bodies, but in the aggregate forming a considerable area of farming land of great fertility. As the rocks vary greatly from ridge to ridge, the soils of the valleys vary correspondingly; but perhaps the most common and important soil of the valleys is that resulting from the weathering of clay slate, which forms a rather heavy and (judging from the tree and shrubby growth upon it) a very substantial soil, often bearing enormous old white oaks, together with the coast live oak (*Q. agrifolia*). The results of cultivation and fruit planting on Baron von Schroeder's ranch, in the hills just west of Cashin Station, have been excellent, the main difficulty being in occasional late frosts where high hills adjoin the valleys. When the country is settled up, many pleasant homes will be made in these mountain valleys.

Location of the Station.—Since from the foregoing observations it appears that not only does the granitic soil occupy the largest area in the region, but that it is of considerable uniformity over its entire cross-section from the Salinas to the Estrella, it seemed proper to locate the station mainly with reference to this predominant soil, and in so doing to consider the convenience of proximity to the railroad. After examining many possible locations it was concluded to accept the offer of Mr. J. V. Webster, of Creston (who had taken the most lively interest in the matter), of a tract of twenty acres lying about two miles north of Paso Robles, three quarters of a mile east from the Salinas River, and about eighty feet above it, on the plateau level; on the main road from Paso Robles to the Huerhuero settlements, and within the region where the adobe knolls project through the granitic sand soil, so as to permit of a representation of both kinds of land within its limits.

The tract, as is shown on the plat (page 104), is a parallelogram one thousand seven hundred and ten by four hundred and ninety-five feet, the latter dimension representing its frontage on the public road, while the longer runs due north and south. The forward (southernmost) two thirds of the tract is practically level, and represents the typical soil of the plains to the eastward; while in the rear third there are two additional soil varieties, to wit: that of the swales in the sandy lands, and on the northwest corner, a triangular, sloping piece of heavy adobe clay land. The latter forms the foot of one of the hillocks already mentioned, on the top of which there is an extraordinarily luxuriant vegetation lasting far into the summer. In the northeast corner is included part of a "hog-wallow" area, the

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soil of which is slightly heavier than that of the front portion, yet not materially different.

Details of the Soils of the Station.—The sandy loam which occupies the larger portion of the experimental tract, and is substantially the same as that of the "Estrella Plains" at large, consists, as already stated, mainly of granitic sand, intermingled with a larger or smaller proportion (according to location with respect to the adobe hills) of white hornstone and claystone debris, most of which are little if at all waterworn. A small but somewhat variable proportion of clay serves as a binding material, which gives the soil enough consistency to turn a furrow-slice, and to prevent leachiness. Grains of quartz, feldspar, and hornstone, from one eighth to as much as one fourth of an inch diameter, occur in the soil and give to the surface, after rains, the appearance of having been strewn with Liverpool salt; they form the bulk of the "coarse materials" mentioned in the analytical statement below. In the finer portions, black or rust-colored grains of partly decomposed hornblende are somewhat abundant.

The tree growth of the tract was almost entirely on the sandy land, forward of the swale, covering about fourteen out of the twenty acres; it consisted almost exclusively of the blue oak, with a few small white oaks; and a few of the larger trees of the former kind were allowed to remain in order to test their production of acorn mast, it being reported that such trees yield a larger amount of hog feed than anything else occupying a similar area. Some of these larger trees were five feet in diameter three feet above the ground, and many between four and five feet.

Aside from the timber growth, the ground was covered with a good deal of bunch grass and alfilerilla (*Erodium*), with the prevailing flora of the region—the several *Phacelias*, *Nemophila*, several *Gilias*, and the blue stargrass (*Sisyrinchium*).

The *surface soil* of the front portion (No. 1147), taken to the depth of twelve inches, is of a reddish gray, or fawn color, which deepens considerably on wetting by bringing out the color of the humus present; but it can hardly be said to assume any plasticity, and could evidently be safely plowed almost at all times.

Northward of the swale, crossing the station tract diagonally, and at about the same level as the front land, there is a piece of sandy land of a somewhat heavier quality than the former, and on which grew a few scattered oaks. Toward the northwest corner of the tract it is underlaid by the black adobe soil of the hillside; while toward the northeast corner it breaks into a "hog-wallow" or hillocky surface, which is common near the heads of the swales in the region. It has, of course, received some of the washings of the adobe hills to increase its clayey ingredient, and its flora differs correspondingly from the front land by the very common occurrence of the yellow hound's-tongue (*Amsinckia lycopsoides*, sometimes called "tarweed," but incorrectly, as it has no sticky secretion but only hooked bristles), which is more particularly at home on the adobe soils.

The soil of the back land (No. 1126) is a gray, silty one, having a certain proportion of coarse sand and gravel up to one fifth of an inch in diameter; darkens but little on wetting, and becomes only fairly plastic, so that it could always be plowed except when *very* wet.

The soil of the swale is more specially described hereafter.

The chemical analysis of these three soils resulted as follows:

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Sandy Loam Soils. Experiment Station, near Paso Robles.

	No. 1147. 12 inches. Front Land.		No. 1126. 12 inches Back Land.		No. 1148. 12 inches. Swale Soil.	
Coarse materials >0.5mm	39.5		20.5		15.3	
Fine earth	60.5		79.5		84.7	
Analysis of Fine Earth.						
Insoluble matter	85.12	90.69	87.26	92.45	81.79	90.31
Soluble silica	5.57		5.19		8.52	
Potash (K_2O)	.68		.40		.60	
Soda (Na_2O)	.31		.35		.27	
Lime (CaO)	.34		.26		.41	
Magnesia (MgO)	.37		.32		.45	
Br. ox. of manganese (Mn_3O_4)	.04		.03		.04	
Peroxide of iron (Fe_2O_3)	3.83		1.68		3.26	
Alumina (Al_2O_3)	1.74		2.93		2.80	
Phosphoric acid (P_2O_5)	.07		.02		.06	
Sulphuric acid (SO_3)	.03		.05		.01	
Carbonic acid (CO_2)						
Water and organic matter	2.19		1.86		2.12	
Total	100.29		100.35		100.33	
Humus	.66		.55		1.16	
Ash	.79		.86		1.28	
Sol. phos. acid			.02			
Silica						
Hygroscopic moisture (absorbed at 15° C.)	1.84		2.50		3.43	

The sandy nature of these soils is well shown in the large proportion of inert matter and the low moisture absorption; the latter is so low in the front land soil, that but for the great depth at all points it would constitute a serious defect, and would necessitate very frequent irrigation. But as there is scarcely a noticeable change in the nature of the soil for eight feet and more, both moisture and nourishment can be sought by the roots independently of the surface soil. As a matter of fact, however, moisture sensible to the hand is always found in this land at a depth of six or eight inches, and the roots of the smaller plants are usually found, unhurt by drought or heat, much nearer the surface. It thus becomes intelligible how this land can be cultivated without irrigation, despite the long, hot, and rainless summer.

Chemically the soil (No. 1147) shows its granitic origin by the abundance of potash present, with, for California, a relatively small proportion of lime, which, however, does not amount to a deficiency in so sandy a soil, and still imparts to it the characters of a "calcareous" one. For so sandy a soil, again, the supply of phosphoric acid is quite large, especially in view of the great depth to which roots can readily go. The supply of humus is only fair and might advantageously (to moisture-retention) be increased. The soil is therefore a very good one of its kind, and likely to be lastingly productive.

As to the sandy soil of the back land (No. 1126), it will be noted that while it contains less of "coarse materials" than that from the front land, its inert portion is greater by nearly two per cent than in the latter; naturally its percentages of each of the soluble ingredients must be correspondingly smaller if the two soils are otherwise similar. The reduction in the essential ingredients is, however, greater than it should be on this ground, as will be seen on comparing the figures for potash and lime; the phosphoric acid percentage is extremely low, but as all of it is in the soluble form, the soil may not show a deficiency in this ingredient for some

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time. Humus likewise is in small supply; the greater clayeyness of the soil is indicated by the higher figure for alumina, and for moisture absorption. Its dead gray tint indicates the relative lack of iron also, as compared with the soils of the adjacent land. Evidently this soil has derived no special benefit from the washings of the rich hilltops above, and thus appears to be on the whole of lower quality than the sandy land south of the swale.

Swale Soils.—There is a marked peculiarity about the soils of the swales of this region, that—rather than valleys with well defined water channels—traverse the sandy mesas of the Estrella Plains. These swales are peculiar in their flora as compared with the adjoining higher ground; their spring flowers are made up almost entirely of a few species, densely crowded together and drying up rather earlier than is the case on the higher ground. These species are the small "star sunflower" (*Baeria chrysantha?*), the small plantain (*Plantago Patagonica*), the purple flame flower (*Orthocarpus attenuatus*), the small-flowered white forget-me-not (*Eritrichium Californicum?*), and the cowslip (*Dodecatheon*). The soil, manifestly formed from the finer wash of the slopes, appears to consist very largely of fine silt with but little clay; becomes close and very hard-baked in summer, and during the rainy season develops the disagreeable peculiarity of "bogginess" to a degree that renders roads in or crossed by such swales almost impassable, and causes it to plow "like putty" when at all wet, sticking to the plowshare and often refusing to turn a furrow-slice. When well tilled the soil appears to produce well, quite equal to the uplands; but in order to get it into condition it would seem necessary to underdrain it, and this improvement has accordingly been made in the middle of the swale that crosses the experimental plot diagonally from northeast to southwest, by the laying of seven hundred and sixteen feet of three-inch tile. The experience of the season of 1889–90 will doubtless demonstrate the result of this experiment.

From its position and manifest origin, the swale soil (No. 1148) should represent the finer portions and leachings of the upland soils (Nos. 1147 and 1126); it should therefore contain more lime, magnesia, and alumina, and less inert matter; and as a result of its position should have more humus, and from that cause, as well as from the higher contents of clay, should have a higher hygroscopic power. It will be noted that this is precisely what is actually shown by the analysis; and although its contents of potash and phosphoric acid are somewhat lower than in the upland soil, these ingredients are doubtless more available. But these advantages cannot avail unless the land is kept in good tilth; and as this is difficult to do in unfavorable seasons unless the land is underdrained, the outcome of cultivation on these swales is thus far on the whole less satisfactory than on the higher ground.

The *mechanical* analysis of this soil, not made in full detail but only so far as necessary to prove its general character, gave the following result:

Mechanical Analysis.

Weight of gravel between 1.2mm and 0.6mm	15.3
Fine earth	84.7
	100.0

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Mechanical Analysis of Fine Earth.

Clay	3.09
Sediment of <0.25mm hydraulic value	18.41
Sediment of 0.25mm Sediment of 0.5mm	6.32
Sediment of 1.0mm	10.34
Sediment of 2.0mm	7.84
Sediment of 4.0mm	8.00
Sediment of 8.0mm	10.04
Sediment of 16.0mm	10.69
Sediment of 32.0mm Sediment of 64.0mm	22.77
	97.50

It will thus be seen that this material, although working like a very heavy soil when wet, contains but a very small amount of clay, as might also be inferred from its still relatively low moisture absorption in presence of over one per cent of humus. It should also be noted that the sediments which form the greater part are very fine, and do not grade off gradually toward the coarser ones, of which there is but little present. In other words, these swale soils belong to that class composed, in analogy to putty, of a large proportion of fine matter with but a trifling amount of binding material (linseed oil or clay); hence, both materials "*work* like putty," resisting inertly the tool penetrating it and clogging it as it goes.

Adobe Soils.—As has been stated, the rear (northwest) corner of the tract contains about an acre of heavy, dark-colored, clay soil, in which deep sun-cracks are formed during the dry season. This patch of adobe land lies at the foot and forms part of one of the oft-mentioned knolls, rising about seventy feet above the general level of the tract, some five hundred feet to northward of the fence corner, and continued into a short ridge some seven hundred feet farther. The entire summit of this ridge is conspicuous for the luxuriance of its vegetation, which embraces a full assortment of the herbaceous plants of the region, closely set and much taller than anywhere else. Despite its elevation, moreover, this ridge and others like it continue green several weeks farther into the dry season than is the case with either the sandy uplands or swales adjacent. The same phenomenon extends (doubtless with the same geological formation) eastward to the Cholame country, according to reliable accounts received. The soil on these hilltops is intensely black when moist, but is filled with white specks ranging from about the size of ordinary rifle powder to that of a hazelnut. The greater part of these white grains is hornstone, rather soft, and in angular fragments; the rest is soft carbonate of lime, partly in the form of "agaric mineral." Both ingredients are obviously derived from the underlying stratified rock, in which the same ingredients alternate in the shaly-bedded layers. The soil is evidently a purely "residual" one, derived from the disintegration of these rocks, into which the subsoil, at several feet depth, forms insensible transitions. In its natural condition, filled as it is with a mat of roots, the soil appears like a sandy loam, easily tilled, but when wetted it becomes extremely adhesive and its color darkens perceptibly; it would manifestly be impossible to plow it in that condition. The analysis of this soil resulted as follows:

No. 1123. Black Adobe, from Hilltop near Experiment Station Tract.

Coarse materials>0.5mm	20.00
Fine earth	80.00

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Analysis of Fine Earth.

Insoluble matter	55.43	73.38
Soluble silica	17.95	
Potash (K_2O)	.77	
Soda (Na_2O)	.64	
Lime (CaO)	5.97	
Magnesia (MgO)	1.03	
Br. ox. of manganese (Mn_3O_4)	.05	
Peroxide of iron (Fe_2O_3)	3.43	
Alumina (Al_2O_3)	5.99	
Phosphoric acid (P_2O_5)	.44	
Sulphuric acid (SO_3)	.07	
Carbonic acid (CO_2)	3.25	
Water and organic matter	5.25	
Total	100.27	
Humus	1.25	
Ash	.47	
Sol. phos. acid	.05	
Silica	.....	
Hygroscopic moisture (absorbed at 16° C.)	10.22	

The most prominent characteristics of this soil are its high contents of lime—nearly 6 per cent—and of phosphoric acid; the latter exceeding all soils thus far analyzed from the Pacific Coast, and approached by only few outside, in the United States. Of this large amount, five hundredths of one per cent (being as much as many good soils contain on the whole) is in the soluble condition. When at the same time we note the high contents of potash and of humus, and the large absorption of moisture (more than five times that of the sandy upland below), we cease to wonder at the luxuriance of the vegetation of these knolls, and the long continuance of their verdure in comparison with the other soils of the locality.

Brown Adobes.—While this hilltop soil is thus one of typical excellence, the area occupied by it is quite small as compared with the lighter colored, usually brownish or fawn-colored adobe soils that prevail on the lower ridges, and often form tracts of considerable extent; as for instance, on the dividing ridge between the Salinas River and the Huerhuero, opposite Templeton, and continuing northward nearly opposite to Paso Robles. The relation of this brown adobe to the profusely fertile hilltops is well shown on the experimental tract, where it forms the foot of the ridge, being clearly a sedentary soil derived from the predominantly clayey strata that underlie the calcareous deposits from which the hilltop soil has been formed. In other words, the brown adobe represents a lower geological level, and one at which the coherence and tenacity of the material has strongly resisted denudation.

These adobe tracts bear in general the same timber growth of blue oak as the granitic soil; the trees are, however, less abundant, and on the whole of inferior size. During summer it tends to open in wide sun-cracks wherever not well shaded or tilled; its natural herbaceous growth is characterized by the great prevalence of the yellow forget-me-not, or "tarweed" (*Amsinckia lycopsoides*), sometimes (as on the experimental tract) to the exclusion of all else, save some clumps of blue star-grass (*Sisyrinchium*). It bears the reputation of being a good wheat soil when well cultivated. On the flanks of the ridges composed of this soil and its underlying materials, the light, granitic soil overlies it. The following record and analyses exhibit its chemical characters:

No. 1149. Adobe upland soil, from the northwest corner of the experimental plot. A very heavy soil, deeply sun-cracked at the time the sample was taken; of a dark brown tint when dry, and cutting with a shiny sur-

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face; almost black when wet, and becoming very tenacious when kneaded. Occupies the lower slope of the adjacent ridge for some forty feet upward; bears a few blue oaks, and is densely covered with the yellow forget-me-not, or tarweed (*Amsinckia*), very luxuriantly developed. Also, some blue star-grass, *Brodiæa*, *Plantago Patagonica*, *Plectritis*, and *Eritrichium*. Sample taken to twelve inches depth.

No. 1150. Adobe upland soil, from the broad dividing ridge between the Salinas River and Huerhuero Creek, five miles out from Templeton, on the Creston road; C. P. Huntington's land. Fairly timbered with blue oak; herbaceous growth nearly as in the preceding number. Appears to be not quite as heavy as the soil on the experimental tract; contains some white hornstone gravel in its upper portion, and seems to become rather heavier downward. Sample taken to the depth of twelve inches.

The chemical composition of these soils is given in the table following; the black hilltop adobe (No. 1123) being placed alongside for comparison:

Adobe Soils.

	No. 1123. 12 inches. Hilltop, near Experiment Station, Paso Robles.		No. 1149. 12 inches. Northwest corner of Experiment Station.		No. 1150. 12 inches. Upland, Huntington Tract.	
Coarse materials > 0.5mm	20.00		13.52		9.36	
Fine earth	80.00		86.48		90.64	
Analysis of Fine Earth.						
Insoluble matter	55.43	73.38	57.69	78.67	55.63	77.20
Soluble silica	17.95		20.98		21.57	
Potash (K_2O)	.77		.70		1.01	
Soda (Na_2O)	.64		.18		.33	
Lime (CaO)	5.97		1.09		1.31	
Magnesia (MgO)	1.03		1.04		1.26	
Br. ox. of manganese (Mn_3O_4)	.05		.04		.03	
Peroxide of iron (Fe_2O_3)	3.43		4.39		7.22	
Alumina (Al_2O_3)	5.99		9.16		6.78	
Phosphoric acid (P_2O_5)	.44		.08		.09	
Sulphuric acid (SO_3)	.07		.01		.04	
Carbonic acid (CO_2)	3.25					
Water and organic matter	5.25		4.67		4.50	
Total	100.27		100.03		99.77	
Humus	1.25		.47		.58	
Ash	.47		.21		.08	
Sol. phos. acid	.05		.03		.03	
Silica						
Hygroscopic moisture (absorbed at 15° C.)	10.22		11.14		10.78	

So far as the essential points are concerned, these soils are very nearly alike in composition as well as in other characters, while very unlike the black soil of the hilltop (No. 1123). Both are, however, well provided with the several ingredients of mineral plant food, and should be productive as well as durable under careful cultivation, which alone will render such heavy soils profitable. A larger proportion of lime would be desirable, especially in No. 1149, which is the more extreme of the two. Both contain much less humus than is desirable in such heavy soil, so that the addition of vegetable matter as well as of lime or marls would materially help their thriftiness. But as they stand, there is no reason why the production of grains as well as of fruits adapted to heavy soils—plums, pears, apricots, apples, etc.—should not be successful.

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Improvements Thus Far Made on the Station Grounds.

The tract has been inclosed with a substantial "six-board" *fence*, of redwood posts, with Oregon pine planks. The latter had been so disposed that it was hoped rabbits would be excluded; but experience showed that this was not the case, and it became necessary to interpose in each of two lower spaces a strand of barbed wire. Unfortunately considerable damage to young trees and vine cuttings occurred before this additional protection could be given.

The *buildings* on the station grounds consist of a dwelling and a barn; the cost of the former was defrayed by subscription from citizens, chiefly of Creston, Templeton, and Paso Robles. The region being very thinly settled, more could not reasonably be expected, hence the barn was erected at the expense of the Station Fund.

The *dwelling house* is a neat two-story frame cottage, rustic-finished; dimensions, about thirty by thirty-eight feet, inclusive of verandas in front and rear; it has eight rooms and bath. The front faces south, toward the county road and main entrance. Several groups of oaks have been left standing around the house and outbuildings, for shade and protection from wind.

The *barn* is placed near the east line of the tract some distance in the rear of the house; is also rustic-finished, sixteen by sixteen feet, with three stalls, and hay loft giving room for five tons of (baled) hay. Adjoining the stable are *wagon* and *tool sheds*, each sixteen by fourteen feet; a space sixteen by forty-eight feet is in addition covered by a lean-to roof, forming an open shed, affording additional space for storing implements, etc., from the weather.

Between the barn and the house is a *dug well* about one hundred and five feet deep and four feet in diameter (with wooden curbing down to forty feet, and brick for seven feet from bottom), which, as a rule, contains about five feet of excellent water. It is at present raised by horse-power with a deep-well force pump into a redwood tank of three thousand gallons capacity, raised on a trestle twelve feet high, for the supply of house and stable. It is intended to supplement the horse-power, so far as the light winds prevailing in the region will permit, by a windmill, in order to save the time of team and men and obtain a larger supply; since at present the latter is too scanty to permit of its free use in such irrigation as is absolutely needful.

As this well is the first one sunk on the plateau near the river, its features and measure of success are of somewhat extended interest. Unfortunately the record kept by the well-digger is very unsatisfactory as to the nature of the materials encountered, but subsequent inspection coupled with it leads to the following result: The greater part of the material penetrated was bluish or whitish clay, very plastic; it alternates irregularly with thin-bedded strata of hornstone, mostly soft but some quite hard, and containing, or alternating with, more or less of calcareous materials. The water comes in through (mostly whitish) hornstone gravel, near the level of the Salinas River bed. It does not appear that any well defined fossils were found here, although at some points, as near Cashin Station above Templeton, oysters and other fossil shells are quite abundant in the siliceo-calcareous strata exposed in the streams. Hornstone gravel conglomerate crops out prominently on the bluffs of the river opposite Templeton, and also near Paso Robles, and doubtless represents the continuation of those found in the station well. The water is somewhat hard (calcareous), but good for all domestic uses.

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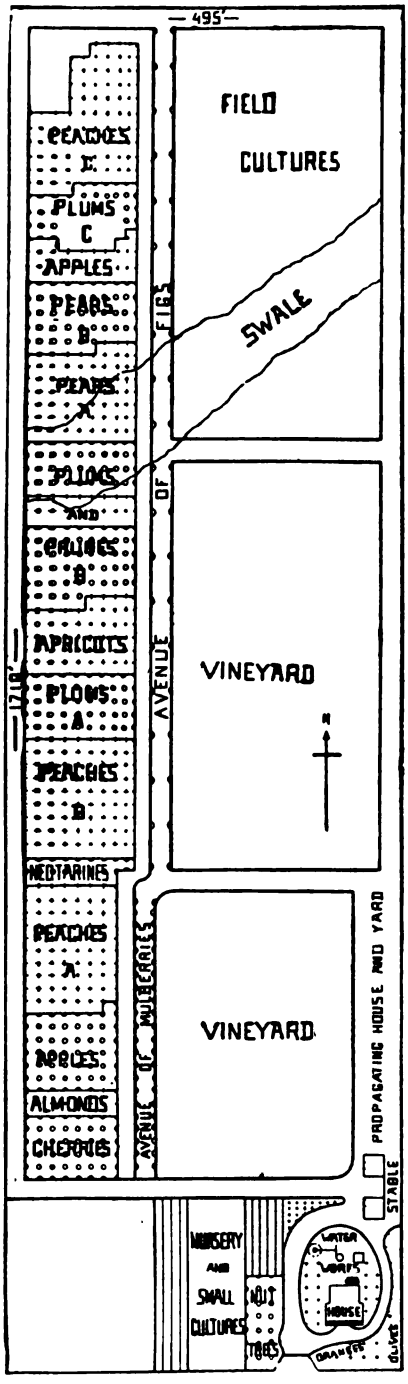

PLAT OF THE TRACT OF THE SOUTHERN COAST RANGE STATION, UPPER SALINAS VALLEY.

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Plan of the Grounds.—The plan adopted in laying out the tract for planting will be best seen from the foregoing diagram.

The space immediately adjacent to the house has been laid out with curved roads and walks, and planted with a variety of trees, as well as with such plants as, whether in propagation or permanent growth, require extra care and watering. Small cultures of all kinds occupy the southwest corner, left in blank on the plat, while between the house and the east fence, under the lee of the oak groves from the prevailing wind, there is a plantation of citrus fruits and olives.

In laying off the vineyard and orchard it was necessary, on account of the long rectangular shape of the tract, to extend these likewise, in order to cover the variations of soil that to a certain extent occur even in the sandy land; and for the same end the several fruits were not planted in solid bodies each, but somewhat subdivided, so as to show, as far as possible, the influence of soil variations. The heavy soil of the swale (see above, description of soils) was divided between pears and plums, as being most likely to succeed in it.

The plot on the northeast corner of the tract, reserved for field cultures, embraces a fair representation of the bulk of the lands likely to be used for such purposes; a somewhat heavier loam than the land occupied by the fruits, yet not of an "adobe" character.

The subjoined report of Inspector W. G. Klee, based partly on the data recorded by the station foreman, Mr. Cruickshank, partly on personal observations, supplies the details of the planting as well as a number of interesting culture data.

NOTES ON CULTURE EXPERIMENTS AT THE SOUTHERN COAST RANGE STATION DURING 1889.

By W. G. Klee, Inspector.

Small Grain.—A large variety of cereals, including thirty-three varieties of wheat, seventeen of barley, eight of oats, and a few of rye and spelt, were planted in small beds on the nursery grounds, it being very much too late in the season to attempt anything on a larger scale. The soil here is very sandy and becomes quite dry, and, taking in consideration that the grains were planted much later than is considered safe for wheat in this section, the results were not without value for future comparisons when planting will be done at the usual times. The following list and notes were furnished by the foreman in charge, Mr. R. D. Cruickshank:

Report on Grains and Forage Plants Grown in 1889.

Variety.	When Sown.	When Ripe and Cut.	Growth and Result.
Wheat.			
Red Sonora	Feb. 12	June 24	Medium.
Russian Red-bearded, Hessian fly-proof	Feb. 12	July 1	Very well.
Royal Australian	Feb. 12	July 1	Fairly well.
Rust-proof Indian wheat	Feb. 13	July 1	Crop good, considering quality of seed.
Whittington's wheat	Feb. 12	July 1	Fair crop.
White Bannat	Feb. 13	July 6	Poor.
Defiance	Feb. 12	July 6	Fair.
Gem or April	Feb. 13	July 6	Medium.
Chili	Feb. 12	July 6	Poor.
California (spring)	Feb. 12	June 24	Medium.
Petali	Feb. 12	June 24	Fair crop.
Palestine	Feb. 12		Failed.

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REPORT ON GRAINS AND FORAGE PLANTS—Continued.

VARIETY.	When Sown.	When Ripe and Cut.	Growth and Result.
Missoyen	Feb. 12..	July 1...	First rate; this and Volo the two best.
Archer's Prolific	Feb. 12..	June 24..	Very well.
Pringle's Defiance	Feb. 13..	July 1...	Good.
Arizona (Indian seed wheat)..	Feb. 12..	June 12..	Filled very poorly.
Volo	Feb. 12..	July 1...	Extra well.
Thuringian	Feb. 12..		Failed.
Tunisian	Feb. 12..		Failed.
Mold's Winter	Feb. 12..		Did not head out.
Propo	Feb. 12..		Destroyed by gophers.
Greek Atlanti	Feb. 12..		Ears did not fill.
Hallet's Pedigree of White Victoria wheat	Feb. 12..		Very few germinated.
Pringle's Best wheat	Feb. 12..		Destroyed by gophers.
Big White Club	Feb. 12..		Did not germinate.
Yellow Noe	Feb. 12..		Germinated weakly and died.
Golden Drop	Feb. 12..		Germinated feebly and failed to head.
Blood Red wheat	Feb. 12..		Failed because of poor seed.
Chiddam wheat	Feb. 12..		Grew feebly; destroyed by gophers.
Michigan wheat, mixed	Feb. 12..		Germinated, but grew poorly.
Rye.			
Saxon	Feb. 12..		Never germinated.
Excelsior Winter	Feb. 12..	July 6...	Did fairly well.
Barley.			
Nepaul	Feb. 12..	June 12..	Extra good.
Berkeley Hybrid	Feb. 12..	June 12..	Medium.
Early Black 2-rowed barley	Feb. 12..	June 12..	Medium.
Scotch 2-rowed	Feb. 12..	June 24..	Medium.
Large Naked 2-rowed	Feb. 12..	June 13..	Extra good.
Manchurian	Feb. 12..	June 13..	Very good.
Himalaya	Feb. 13..	June 13..	Very well.
Bluish barley	Feb. 12..	June 13..	This did best of all our barley; much admired by visitors.
Chevalier	Feb. 12..	June 24..	Only medium.
Imperial	Feb. 12..	June 24..	Medium.
Italian	Feb. 13..	July 13..	Nearly a failure.
Scotch Annate	Feb. 12..		Entire failure.
Six-rowed	Feb. 12..		Entire failure.
Carter's Prolific	Feb. 12..		Poor; plants eaten by gophers.
Six-rowed Winter	Feb. 12..		Entire failure.
Black 6-rowed	Feb. 12..	July 6...	Showed exceedingly well, but was mostly taken by birds before maturity.
Rice or sprat	Feb. 13..	July 6 ..	Nearly a failure.
Oats.			
Scotch Hopeton	Feb. 13..	July 6...	Poor.
Surprise	Feb. 12..	July 1...	Very good.
Gray oats from Houdan	Feb. 12..	July 6...	Good.
Black Tartarian	Feb. 12..	July 6...	Very good.
Early August	Feb. 12..	July 6...	Very good.
Black oats from Coulomières	Feb. 12..	July 6...	Fair, but was taken by gophers.
Early oats from Etampes	Feb. 12..	July 6...	Short, not good.
Spelt.			
White Emmer	Feb. 13..	July 6...	Very poor.
White Silesian	Feb. 12..	July 6...	Very poor.
Grasses.			
Hungarian Brome	Feb. 13..		Doing well; much eaten by rabbits.
Tall oat grass (*Avena elatior*)	Feb. 13..		Grew fairly well; looks dry in September.
Japanese wheat grass (*Agropyrum Japonicum*)	Feb. 13..		Grew well, but is now quite dry.
Schrader's Brome grass	Feb. 13..		Seems to do well.
Chick pea (*Cicer arietinum*)	Feb. 13..	June 13..	Does remarkably well; finer crop than I have ever seen in India, although grown there in immense quantities for food for man and beast.
Snail clover (*Medicago turbinata*)	Feb. 13..	June 13 ..	Did first rate, and likely to be a very useful addition to pasture.

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REPORT ON GRAINS AND FORAGE PLANTS—Continued.

VARIETY.	When Sown.	When Ripe and Cut.	Growth and Result.
French lentils	Feb. 13	June 13	Did very well.
Tagasaste (*Cytisus proliferus albus*)	Feb. 13		Germinated and came on well, but the rabbits have eaten it off. It would do well here.
Sainfoin	Feb. 13	June 1 (flow'r'd)	Coming on well, and will stand drought.
Teosinte (*Reana luxurians*)			Will do well for this section. Has formed dense tufts six to twelve inches high, but without water grows rather slowly.

Corn.—All varieties planted have done poorly, the product not being worth mentioning. This is in part due to late planting, but it should be noted that this section is not considered good for corn (maize); the plant succeeds without irrigation only on the moist bottom lands, and nearer the coast, where the air is moister.

Sorghums and Sugar Canes.—This class of plants, which usually succeeds where Indian corn, for lack of moisture, cannot, has done proportionally better, but was evidently also planted too late. The leaves dried on the edges, and, except where receiving artificial watering, they cannot be said to have succeeded.

"*Kaffir Corn.*"—The latter seems to blight in bloom, and produces, even with irrigation, a poor head. Another season, with more timely planting and better prepared ground, is necessary to settle the adaptability of sorghums for the soil and location in question. Mr. J. V. Webster, the Patron of the station, living twelve miles east of this place, reports very good results with sorghum cane as fodder. Of those tried he finds the Early Amber the best. This, however, is on land having water at from five to six feet. White Egyptian corn blasts in bloom. Kaffir corn does not do well, also blasting in bloom, and its growth is very short. For swine feed Mr. Webster considers the Early Amber cane very profitable.

Grasses.—Of the grasses mentioned in Mr. Cruickshank's report, I found the Japanese wheat grass (*Agropyrum Japonicum*, Vasey) well started after the rains in October, as also Schrader's Brome grass and Sainfoin, while the tall oat grass (*Avena elatior*) had survived only in part. A full assortment of the best varieties of grasses and forage plants is now being planted at the station, and it is hoped that some of these will prove suitable. Those that survived last year will be planted on a larger scale. I find here, as in most places in California, the keenest interest in the subject of forage plants.

Bamboos.—Near the house and tank several bamboos were planted. Of some lately imported so called "Giant Bamboo," none grew. However, two varieties, transplanted from Berkeley—a Japanese named Metake and a Chinese large-growing kind—have succeeded well, with copious watering.

Orchard.

There have thus far been planted about four hundred varieties of deciduous fruit trees (including nuts), and a collection of small fruits.

Training of the Trees.—The low trunk system has been adopted uniformly for these trees, it having been proved by experience that the climate of the larger part of California demands it. Of failures from not following

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this system there are ample illustrations in San Luis Obispo County, as in every county in the State. The trees were cut off at a uniform height of three feet, allowing a space of eighteen inches or less for trunk, and the remainder for the formation of a head.

Apples.—Ninety varieties, including crab-apples, have been planted, one of each. The collection embraces nearly all the varieties which have been found adapted to the various climates of the State; also some new introductions from Texas. With few exceptions the growth has been uniformly good, especially on the granitic, sandy land, less so on the heavy adobe. But one or two have died; no attacks from the flat-headed borer (*Chrysobothris*) have been noticed. The trees in the whole orchard have been shaded with shakes on the south and west sides.

Cherries.—Thirty-eight varieties were planted; a few duplicated on Mahaleb stock, but the rest on Mazzard stock, the kind now almost exclusively used in this State. The growth of these trees has been very good, only a few failures to be recorded; they were planted on well drained land.

Pears.—The collection embraces sixty-five varieties; besides these some seedlings of common and Japanese pear stock were planted for future budding. The growth of the pears has been only moderate; but very few have been lost, except of the small pear seedlings planted very late (in April). The soil in which the pears are growing is heavy. Although planted very late, the Japanese pear seedlings have done very well, and are promising.

Plums and Prunes.—The growth of these has been only moderate; of most of them poor. Of seventy varieties, yearling trees, one or two of each, fifteen have died. This must be chiefly attributed to very badly drained soil,* also to late planting. Of the sixty-two dormant buds on Myrobalan stock planted, only twenty-two made any growth, although the remainder are alive at the root. The chief cause of failure was too late planting, as the growth of the buds of the living trees has been pretty fair. The Japanese plums have done remarkably well on the whole. It is the intention to test the question of stock pretty thoroughly, in regard to prunes especially, and the kinds not represented will be planted this season.

The matter of grafting stock is very important in more than one respect. Not alone in regard to the adaptability of certain kinds to soil, but also in regard to their probable influence on the scion in time of ripening and development of the fruit. I learned on my visit this fall the singular fact of the comparatively late ripening of some French prunes near Creston, also their tenacity in remaining on the trees. Knowing that the same is the case in the upper San Joaquin Valley, I was curious to investigate further; and through the kindness of Mr. Cruickshank learned that such has been the experience in a number of localities in the county. There seems to be a parallel case here in two sections, in many respects very unlike. That is, we meet with late ripening plums, prunes, and pears both in the unirrigated tablelands of San Luis Obispo and in the irrigated or sub-irrigated plains of Tulare and Kern; while in both places peaches, apricots, and grapes, and almost everything else, seem to follow what one might think the natural course—early ripening, stimulated by heat. The case is a little difficult to explain, although the explanation may be that the high temperature produces a sort of resting period, and that its influence is felt chiefly on the fruits from the colder regions, such as pears and plums. Whatever the true cause may be, it is of consider-

*This portion of the grounds has now been drained by laying of tile drains, and it is hoped this will obviate future trouble of excess of water.

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able practical importance to fruit growers, especially to the prune grower; and if certain stocks would cause the fruit to mature a little earlier and separate easily, so as to allow it to be shaken off, as is the universal practice in prune sections, it certainly would be of advantage by greatly reducing the cost of harvesting.

Peaches.—Some sixty varieties on peach root, with some on plum stock, have been planted. The growth of these yearling trees on the first named stock has been very satisfactory, the granitic soil suiting them well. The dormant buds on Myrobalan have, however, been very unsuccessful. The soil in the spot chosen is quite heavy and wet, and as they were planted very late it is difficult to say whether the failure is due to soil, late planting, or to unsuitable stock. It may be argued with reason that soil of a heavy nature is not suitable for the peach, and plenty of soil exists that is; but nevertheless, many a farmer and small owner might like to have a few peaches and not have any suitable peach soil. There is another and more formidable and less known reason why we ought to settle definitely which peaches will succeed on plum stock, namely, the appearance a few years ago of a peach root borer, closely allied to the peach borer of the Eastern States, and which has been very destructive in many sections. Using plum stock has been at the East one of the preventives for this pest. It is probable, of course, that our peach borer species will eventually spread all over the State, although indications are that it will prove very destructive only on heavier soils. The greater part of the dormant buds which failed will be replaced with yearling trees grown this year in Berkeley.

Nectarines.—The nectarines, of which ten varieties were planted, started well, but have been interfered with by "varmints," causing more than natural loss. A like number of nectarines in dormant bud on the Myrobalan stock did not fare much better than the peaches on the same stock.

Almonds.—The almonds, on the whole, have done remarkably well, the growth being very good—the strongest of any fruit tree planted. The foliage, also, is remarkably good, showing no sign of being affected by mites (red spiders), the natural enemy of this tree. In spite of the majority doing well, a few trees have been lost, for what reason I am not quite prepared to say. There were planted ten varieties, including our best California seedlings.

Apricots.—The collection of apricots, twenty varieties, on apricot root, has not been a success. A portion of the trees planted in stiff soil, bordering on the swale, have suffered severely. The young roots were evidently killed by the excess of water in the soil, and when the trees started out the foliage was blighted by the dry wind and hot sun. Mr. Cruickshank states that water stood here for a long time, and adds, that apricots generally do well about Paso Robles. The apricots on Myrobalan stock, dormant buds, did not succeed, numerically, better than other varieties, only seven out of twenty growing into trees. Taking in consideration, however, the late planting and the excess of moisture these little trees had to endure, the growth of the few surviving ones has been very fair, and will warrant the replacement of the dead ones by yearling trees from Berkeley. That the Myrobalan plum stock cannot be recommended for the prevailing soil (the granitic), at least not for peach and apricot, seems quite clear from the results of Mr. Webster, at Creston, who has a number of apricots on this stock. These trees have never done well, and are stunted beside other apricot trees planted later and on their own root.

Quinces.—These have made moderate growth with some irrigation. They have established themselves in the ground, and will probably get along

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without water next season. Seven varieties besides the Japanese are on hand, all of which are living.

Walnuts and Pecans.—All the walnuts, including seven varieties of the English, two grafted on the California black walnut stock, have lived, receiving some irrigation. The growth, however, has been very slow, compared with that in the humid region on the immediate coast. In this section, as in all others sufficiently removed from the effect of drenching fogs, the walnut suffers invariably from the effect of the mites (red or white). The damaged leaves fall prematurely, and the tree becomes unhealthy. I believe that when this insect is held in check by frequent applications of clear water to the leaves, or washing with sulphide solutions, one of the difficulties of growing the walnut in the interior will be removed.

The pecans have almost all lived.

Filberts.—A number of varieties, six in all, were planted in the partial shade of oaks; but, in spite of frequent waterings, but few have lived. The air seems too dry for them. On north slopes, in the Coast Range, west of the station, the conditions seem more favorable.

Japanese Persimmons.—Some twelve varieties, imported direct from Japan, have, by irrigation, survived the summer, but have made very little growth.

Mulberries.—Mulberries of all kinds have grown well without irrigation; in fact, before the rains, were the brightest looking trees on the grounds. Their success is very encouraging to silk culture. The collection embraces almost all of the cultivated varieties.

Pomegranates.—A few bushes planted have done very poorly. I think the soil was a little too dry for them when planted.

Small Fruits.

Gooseberries.—Both American and English varieties were planted. In the fore part of the summer they did very well, but later on suffered severely from the heat, several dying. On low lands about Paso Robles, they do well.

Currants.—Most of these suffered severely from the heat, and many died.

Raspberries.—Some of these bore fruit, but afterwards died. They, like many other things, were undoubtedly planted too late.

Blackberries.—Nearly all of these died; chief cause, late planting, as blackberries well established do well here.

Strawberries.—What was said of blackberries refers equally to this fruit. With plentiful irrigation they do well.

Miscellaneous Trees.

The *Camphor Tree* planted died during the summer.

The *Strawberry Tree* (*Arbutus unedo*) has made a feeble growth.

Pawpaw (*Assimina triloba*).—Two trees of these; both died.

Black Wattle (*Acacia decurrens*).—Both trees died, evidently having suffered in transit.

Kai Apple (*Aberia Caffra*).—Both plants are doing well.

Citrus Trees.—In the southeast corner of the tract, near the house, and somewhat protected by the buildings and surrounding trees, have been planted a number of sour orange trees, originally imported from Florida, but grown one year at Riverside, San Bernardino County. These trees having come from Riverside without any ball of earth, in the month of April, were slow in starting; but the majority of them have leaved out quite well during the last months of the season. Being rather tender, it

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has been found expedient to shade them with cotton cloth all around. These trees have been irrigated liberally. A few budded orange trees have also been planted.

Olives.—Of these some twenty varieties, mostly two-year old trees, grafted on the so called Redding Picholine, have been planted along the line of the east fence. They have been placed about thirty-two feet apart, to give ample room for future growth. They have done fairly well, and being now thoroughly established, will make a good showing next year. Of their adaptability to this section there is little doubt. They have received sparing irrigation.

Vineyard.

The vineyard, as the map shows, is divided into two parts by an avenue. The collection of vines consists of about one hundred varieties of wine, raisin, and table grapes, mostly belonging to *Vitis vinifera*, only a few American vines having been planted. About one third were rooted vines, most of which have established themselves, some of them making a good growth. The other part of the vineyard was planted with cuttings; of these the majority started well, but have suffered severely from the attack of rabbits; the fence, as stated elsewhere, was not quite close enough. The vineyard is planted eight by eight feet, with an avenue of sixteen feet; thirty vines of each variety. Of the following list of ninety-six varieties the proportion of growing and lost ones stands thus:

Rooted Vines.

12 varieties	No failure.
10 varieties	3 per cent loss or below.
8 varieties	10 per cent loss or below.
3 varieties	16 per cent loss or below.
1 variety	35 per cent loss.

Cuttings.

1 variety	None.
4 varieties	5 per cent loss or below.
5 varieties	10 per cent loss or below.
19 varieties	25 per cent loss or below.
12 varieties	35 per cent loss or below.
13 varieties	50 per cent loss or below.
8 varieties	65 per cent loss or below.
3 varieties	75 per cent loss or below.

It will be noted that the percentage of failure of rooted vines compared with the cuttings is very small, as might naturally be expected. They had, besides, in their favor, earlier planting. The majority of these vines were rooted at Mr. Webster's place, at Creston. The cuttings were sent from the experiment stations at Cupertino and Mission San José. A few were procured from elsewhere. It is amongst these the heaviest loss is noticeable, as they came much later than the rest. Some injury must be attributed to wild animals, such as squirrels, rabbits, and muskrats.

General Results.—When taking in consideration the unavoidable delay in collecting the large variety of plants, and also the late start in getting the grounds in order, the general results must be considered encouraging. The ground in the orchard and vineyard has been kept in good cultivation all summer, and no irrigation has been used except in cases mentioned. The place has a neat and attractive appearance. All trees and vines have been plainly labeled by Mr. Cruickshank, and bear testimony to care and forethought in their treatment.

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THE SAN JOAQUIN VALLEY STATION.

Location: One mile southeast of Tulare City.

The San Joaquin Valley.—The division of the Great Valley traversed by the San Joaquin River constitutes about three fifths of the whole. Its area from the southern end to the Calaveras River, a distance of about two hundred and forty miles, is about eleven thousand square miles.

The climate of the San Joaquin Valley stands in marked contrast to that of the immediate coast of California, and most markedly with that of the bay region contiguous to the Golden Gate. A very light rainfall, decreasing from about twelve inches at Stockton, San Joaquin County, to about five inches at Bakersfield, Kern County; a very dry atmosphere, especially in summer (mostly below 50 per cent of saturation); and a summer temperature, which by the thermometer is very high, but which in consequence of the dryness of the air is but rarely oppressive, and despite of which sunstroke is almost unknown. These constitute the main factors of the climate of the interior valley, in which irrigation becomes more and more needful as we advance southward, and south of Merced County may be said to be indispensable to any safe and rational system of agriculture.

The subjoined table gives the temperature and rainfall data, as far as deducible from the observations made thus far, at three central points in the three counties of the Tulare Basin:

Table showing the Rainfall and Average and Extreme Temperature for Summer and Winter in Tulare Valley. From observations ending June 30, 1888.

Locality.	Elevation—Feet.	Years of Observation.	Rainfall—Inches.	Winter Temperature.				Summer Temperature.			
				Average Maximum.	Average Minimum.	Extreme Minimum.	Average Mean.	Average Maximum.	Average Minimum.	Extreme Maximum.	Average Mean.
Fresno	292	11	8.6	69.5	31.7	20.0	50.7	107.5	60.8	113.0	83.7
Tulare	282	14	6.7	69.2	29.4	17.0	47.1	106.0	62.2	114.0	83.5
Bakersfield	415	14	5.1	72.9	29.8	18.0	49.1	107.3	62.8	113.0	85.2

The absolute extremes given in this table are taken from the observations of six years only, including therein the extraordinary minima of the winter of 1885–6, unequaled for thirty years, where observations have been made for that length of time. The "average minima," deduced from the lowest temperatures observed each day during the winter months, convey a more correct idea of the usual expectation of winter cold.

It should be added that the summer nights are usually quite cool as compared with the days, on account of the cool air descending from the mountains at night; hence, sleep is rarely disturbed by heat, as is so commonly the case in the East.

The *winds* in the entire valley are prevalently from the north, very regularly so during the summer, being simply the trade winds of the coast,

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entering the valley through the Straits of Carquinez and deflected by the mountains, southward into the San Joaquin, and northward into the Sacramento Valley. These up-valley winds are mere breezes, usually springing up in the afternoon and materially tempering the heat. Quite different are the true north winds, or "northers," which are sometimes experienced here as elsewhere in the State, at times blowing with considerable velocity, very hot and dry in summer, cold in winter. The rains of winter are almost invariably from the south, and naturally of short duration. A cloudless sky is, of course, the rule.

The Tulare and San Joaquin Basins.—The prominent *topographical* feature of the San Joaquin, as against the Sacramento Valley portion, is the lake basin formed in its southern half by a low water-divide which crosses the valley in the southern half of Fresno County, and by which the waters of Kings River are thrown southward into Tulare Lake. Northward of this divide the San Joaquin River enters the valley from its cañon in the Sierra; and first crossing it to within a few miles of the opposite slope of the Coast Range, turns northward in the trough of the valley, receiving thereafter the entire drainage of the Sierra. The southern valley is thus subdivided into the southern, or *Tulare Basin*, and the *San Joaquin Basin* proper.

At present, the cross ridge mentioned is intersected at its western end by Cole, Steamboat, and other sloughs or channels, through which the surplus waters of Tulare Lake or Kings River can find their way to the San Joaquin. Previous to the formation of these outlets, the entire upper valley was evidently for some time a shallow lake, of which Kern, Buena Vista, and Tulare Lakes, with their bordering tule marshes, are the remnants. The main tributaries of this basin, heading in the Sierra itself, are the *Kern*, *Kaweah*, and *Kings* Rivers, which carry running water throughout the year. Besides these, there are numerous minor watercourses, of more or less intermittent character, heading in the foothills and reaching the main valley trough only in time of flood, or not at all. Such are Poso, White, and Deer Creeks, and Tule River, which can be relied on for irrigation only to a limited extent. All the streams are bordered by more or less of moist lands, requiring less irrigation than the higher portions of the plains.

The streams of the Tulare Basin enter the valley from the Sierra cañons in remarkably shallow channels, but then cut deeper ways in the plains proper, again approaching the general surface as they near the trough, which lies quite close to the valley's western edge, near the foot of the Coast Range. The streams descending from the latter are of the most intermittent character; the slopes of the Coast Range being steep, bare of forest, and generally very sandy, imparting a corresponding character to the soils of the west side. Hence, the Coast Range streams mostly lose themselves before they reach the trough, and are, in any case, available for irrigation only locally and to a limited extent, unless winter-stored. Nearly the same character of the Coast Range slopes and drainage continues in the San Joaquin Valley proper to San Joaquin County; while the streams flowing from the Sierra, on the contrary, lie there in deeply cut channels for many miles out from the mountains, and do not approach the level of the plain until shortly before reaching the trough of the San Joaquin River, when they take a turn northward.

The *Tulare Basin*, with which the station established is more specially concerned, is terminated on the south by the amphitheater of the Tejon and Tehachapi Mountains, which rise from the valley with rather a gentle slope of good grazing lands, though bare of timber in their lower portions. Conforming in shape to the base of the mountains, but separated from the

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latter by a gently sloping plain eight to ten miles wide, lies the V-shaped trough of lowland in which Kern and Buena Vista Lakes form sheets of water, at present rapidly decreasing, and disconnected from each other by the lowering of the water level in consequence of evaporation. From the same cause these waters are sensibly alkaline, and of course increasingly so as the evaporation progresses, the same characteristic being imparted to the shore lands left by the waters. At the western end of this terminal trough, Buena Vista Slough connects (or connected) the lake of that name with Tulare Lake. This slough at one point (Cole's Bridge) touches the base of a projecting spur of the Coast Range, but below (northward of) that point is bordered by a broad belt of tule lands reaching to the head of Tulare Lake.

Within the angle of the "V" mentioned above, lies what is known as Kern Island, being mainly the delta of Kern River included between its ancient and modern channels, the former of which led directly into the eastern end of Kern Lake, while the latter strikes Buena Vista Slough several miles below the lake of that name.

Kern River, after leaving its precipitous cañon, flows mostly between gravelly bluffs, one hundred to two hundred feet high, for eighteen miles before reaching the valley proper. From this point there diverge a number of channels, seeking an outlet into the lakes; the distance from its present main outlet to the cañon mouth being about forty miles. From about five miles below the cañon the river bed is composed of shifting quicksands, varying in width from one hundred and fifty to eight hundred feet; the banks are low, sandy, and unstable, and the land slopes rapidly away from them, offering great facilities for irrigation; hence there is no other river in the State from which so many canals and ditches have been made to divert the water; their excessive multiplication having given rise to great waste. The higher lands bordering the eastern foothills, as well as the higher parts of the plains farther out into the valley, have not been irrigated thus far, the water being exhausted by the claims made for the lower lands. Winter storage alone could supply this deficiency. As a whole the lands of the Kern River Valley are highly productive sandy loams, in which, despite the greater or less prevalence of alkali, both field and fruit crops reach great perfection.

The heads of *Poso Creek* and *Tule River* extend but a short distance back into the Sierra, and hence the waters, even of the latter, are usually swallowed up in its sandy bed and tule swamps before reaching far out into the plain. An old channel, forking off to the north toward Elk Bayou of the Kaweah, is bordered by a belt of "black land" (see below). Tule River supplies important irrigation works in the neighborhood of Porterville, lying within the "red lands" hereinafter described.

The *Kaweah River*, like the Kern, forms an extensive delta between the foothills and the valley trough, to which indeed it has at present no definite main channel. It begins to spread out immediately upon leaving its rocky cañon, within the foothills, and loses a considerable portion of its waters in the beds of sand, gravel, and light alluvium with which it has built up the valley for nine or ten miles from its point of emergence, with a width varying from two to three miles, and a fall of sometimes as much as thirty feet per mile. On clearing the foothills it spreads out like the fingers of the hand, into a maze of creeks and minor channels, to an extreme width of nearly twenty miles, while the distance to the (present) margin of the lake is thirty-six miles. The total fall from the mouth of the cañon is about three hundred and thirty feet; from the foothills, one hundred and ninety feet; near the lake the fall is only about five feet per mile. The creeks that carry the water down this great sloping delta plain

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sometimes disappear in beds of sand, and reappear below under another name; sometimes are altogether lost in swampy tracts, densely covered with a fine growth of white oak and underbrush. The Kaweah delta is the one really wooded region in the San Joaquin Valley, the trees attaining a very large size. Elsewhere in the valley a few scattered oaks are all that is usually seen away from the main channels of the streams. A portion of the lower lands (old alluvium of the Kaweah and its sloughs) can be cultivated without irrigation, and in the higher and sandier lands, as near Tulare City, the water table is within twelve or fourteen feet of the surface, and can therefore be easily made available for irrigation. From the several creeks numerous ditches run out, using all the water except in time of flood.

Kings River, both from its location with reference to the adjoining country and from the volume and purity of its water, is one of the most important irrigation rivers of the State. Immediately on leaving its cañon it subdivides into several channels not widely separated; but from a point about three miles out it begins to spread and forms a wedge-shaped alluvial region, three miles in maximum width and ten miles long, known as the "Centerville Bottoms." Below these it reunites and continues in a single, deep, tortuous channel, twenty to sixty-five feet below the surface of the adjacent plain, for twelve miles (direct line), when Cole Slough forks off to the southwest. Ten miles below this point the river again spreads out into complex sloughs and channels, traversing an alluvial (delta) region, which, from the southeastern limit of the Mussel Slough country, near the mouth of Cross Creek to the junction of the North Fork with Steamboat Slough, measures about twenty-seven miles across in a southeast and northwest direction, and from northeast to southwest over twenty miles, from the divergence of Burris' Slough to the western border of the valley trough. On reaching the latter the main channel of the river turns squarely southeast, toward Tulare Lake, which its waters may reach or not, according to the season, the rainfall, and the greater or less use of irrigation water in the upper portion of its course. From the turn of the river toward the lake there extends in the opposite direction (northwest), for thirty-six miles, a belt of alluvial (mostly "tule") land, averaging four miles in width, which is intersected by numerous more or less definite channels, of which Steamboat Slough is the principal one, and it continues some eight miles beyond the tule belt, to the northwestward turn of the San Joaquin River, into which any surplus is discharged in time of flood. Kings River has not a single perennial tributary from the foothills to Tulare Lake, a distance of about sixty-two miles.

Between Kings River and Cross Creek (the northernmost branch of the Kaweah), and Tulare Lake on the south, lies the Mussel Slough country, long noted for its fertility, and irrigated by many ditches from Kings River. The soil of the Mussel Slough country is mainly a light alluvial loam of great depth, quite distinct from the soils of the higher plains, and doubtless represents an ancient delta of Kings River, formed before the latter had any direct communication with the San Joaquin, but flowed farther south, directly into Tulare Lake.

A very large proportion of the water of Kings River is now diverted from the upper portion of its course toward the plains of Fresno, lying from fifty to sixty feet higher than the Mussel Slough plains, and differing materially in their soil characters from the latter, as well as from the higher plains of the San Joaquin Valley at large.

Soils of the San Joaquin Valley.—The higher plains have very uniformly, from Kern County to Stanislaus, a very sandy loam soil, of great depth, and almost everywhere made up of granitic debris instead of quartz grains;

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hence continually increasing their store of mineral plant food by the weathering of the minerals present, a process which in so porous a material, subject, in its natural condition, to free access of air during the greater part of the season, was evidently very rapid, and as a consequence has developed unusually large amounts of the soluble products, which often appear in an inconvenient abundance in the guise of "alkali." But little trouble arises from this cause in the high-lying, sandy tracts, where irrigation or the natural rainfall carries the soluble salts annually into the country drainage; but in the low-lying and less pervious soils of swales and valley troughs, which are at the same time intrinsically the richest in available mineral plant food, the accumulation frequently causes considerable trouble and difficulty. There is on the whole, however, but little of the heavier class of clay or adobe soils to be found in the San Joaquin Valley; what is currently so designated would in other regions sometimes be hardly classed as a clay loam. A narrow belt of dark-colored clay or adobe land extends from the neighborhood of Merced City toward Stockton, where, northward of French Camp Slough and especially westward to the Coast Range, really heavy adobe or prairie soils prevail very largely. To southward of the line of San Joaquin County adobe soils are found only in the river trough, and the soils of the west side are prevalently sandy, all the way to the Tejon Mountains.

Soils of the Tulare Valley.—The variety of soils occurring in the valley and their relations to each other can be best illustrated by detailed cross-sections from the Coast Range to the foothills of the Sierra.

A section near Bakersfield, across the Kern delta or "island," does not present a great variety. The slopes of the Coast Range across Buena Vista Slough are quite sandy, full of loose fossil shells, and at some points show the blooming out of alkali salts. The surface is covered with greasewood bushes, and but little grass, more probably because of lack of moisture than want of strength in the soil, judging by the luxuriant growth of the greasewood.

The soil of the valley of Buena Vista Slough is a fine clayey sediment of blackish tint, and although not very stiff, is here called "adobe," by comparison with the prevailing sandy soils. Its luxuriant vegetation leaves no doubt of its high productiveness; but the valley is quite narrow, with a gentle slope up to the level of the plains on the east. Here the upland soil bordering the valley and for some miles inland is quite light, a rather fine sand almost exclusively overgrown with salt or alkali grass, and showing the presence of "black alkali" wherever water has evaporated; it is, however, said to produce forty bushels of corn per acre without difficulty, at first.

The analysis of this soil gave the following result:

Coarse materials>0.5mm	None.	
Fine earth	All.	
Analysis of Fine Earth.		
Insoluble matter	87.06	89.04
Soluble silica	1.98	
Potash (K_2O)	.49	
Soda (Na_2O)	.35	
Lime (CaO)	1.20	
Magnesia (MgO)	1.07	
Br. ox. of manganese (Mn_3O_4)	.03	
Peroxide of iron (Fe_2O_3)	5.82	
Alumina (Al_2O_3)	.17	
Phosphoric acid (P_2O_5)	.08	
Sulphuric acid (SO_3)	.13	
Carbonic acid (CO_2)		
Water and organic matter	1.13	
Total	99.51	

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Humus	.17
Ash	.20
Sol. phos. acid	.01
Silica	
Hygroscopic moisture (absorbed at 15° C.)	2.16

The characteristics of this soil, as compared with others of the region, are the low contents of alumina and humus, in which respect the soil stands alone thus far in this State. It has practically no clay in its composition; its humus has been dissolved out currently as formed, by the "black alkali;" and its sand, as inspection shows, is not of the granitic character seen elsewhere, but consists mainly of quartz grains only. Its retentiveness of moisture is very low, and is maintained as it is largely by the presence of alkali salts. Nevertheless, it shows by analysis respectable percentages of potash, lime, and phosphoric acid; and it is probable that if the black alkali were neutralized by means of plaster so as to permit of the retention of humus when formed by the plowing-in of green crops, it could be cultivated profitably.

To eastward of the "salt-grass belt" (about two miles wide) the land continues to rise and the soil becomes more coarsely sandy, while alkali grass becomes more rare, and sweet grasses, alfilerilla, and the rest of the usual growth of the plains appear. At the Belleview Ranch, twelve miles toward Bakersfield, the prevailing soil is still that of the higher plains, consisting mainly of granitic sand, forming a sandy loam at the surface and lower down growing coarser and less clayey, showing plainly the rock materials of which it is composed. The great productiveness of this soil under irrigation has been amply shown by experience; its composition is doubtless similar to that of Tulare, hereinafter discussed.

Eastward from Belleview Ranch, toward Bakersfield, the alluvial soils of the Kern River delta soon begin; dark-colored, more or less sandy, but very substantial and productive loams, which are best seen farther to southward on the Livermore Ranch, as the characteristic soils of Kern Island. To the southeast of Bakersfield is the "weed patch" of Kern River, an old alluvial area into which water now flows only in time of flood, and the extreme richness of whose soil is indicated by the phenomenal growth of weeds wherever the land is left to itself. The soil of the "weed patch" is said to be similar to the "adobe" seen on Buena Vista Slough; while the soil of the border, and dry bed, of Kern Lake is a highly calcareous, silty mass, rather light in weight when dry, and perhaps more of the nature of a marl than a soil proper, being largely made up of the debris of shells. It is chemically, doubtless, similar to the soils of the Tulare Lake border.

Crossing Kern River and the railroad, we again come upon the coarser sandy or granitic soils of the higher plains, and within a few miles begin to ascend the foothill slopes. Here these show none of the red soil so characteristic elsewhere, nor is the proverbial "bedrock" or foothill slate to be seen; the country rock, horizontally bedded, is a whitish, chalky-looking sand- or clay-stone, not very highly calcareous, and alternates with beds of a dark-colored clay, bearing more or less gypsum in the form of "isinglass," or selenite crystals. Some miles above these clays give rise to a very important surface deposit of impure gypsum, well adapted to agricultural uses, which is described elsewhere. It seems quite likely that the neutralization of the "black alkali" by the leachings of the gypseous hills has had something to do with the extraordinary luxuriance of plant growth in the "weed patch."

Tulare City Section.—The section across the valley in the latitude of *Tulare City* includes a portion of the delta of the Kaweah River, as that

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near Bakersfield does Kern Island. Here a sloping plain, sixteen to twenty miles wide, intervenes between the northern half of Tulare Lake and the Coast Range, the foot of which was, however, washed by the southwestern corner of the lake when high. The soils of this west-side plain are described as being very sandy, but productive when irrigated, for which purpose the watercourses of the Coast Range are unfortunately altogether inadequate.

East of the lake, we successively traverse, in traveling toward the Sierra foothills, the following belts of land:

1. Lake-border lands, similar to those now laid bare in the recession of Tulare Lake; width, about twelve miles; treeless.
2. Black lands, ancient lake alluvium; width, about ten miles; mostly treeless.
3. Sandy "plains" lands, alternating with bands or islands of "salt-grass" land; width, east and west through Tulare City, about seven miles; all more or less wooded (with white oak), some densely so.
4. Another belt of "black land," precisely similar to that west from Tulare City, forming, along Elk Bayou, a belt two to three miles wide.
5. Between the present and ancient channels of Elk Bayou or Outside Creek, an island (about one and a half miles across and four and a half miles long) of alkali land covered with salt bushes.
6. Between the old channel and the foothills, a belt of "red lands," with a soil similar to and derived from the foothills, and forming a sloping plain; width, eight to ten miles; practically treeless.

These several belts are described in detail below:

The *lands of the immediate lake-border* are quite peculiar, varying, of course, from place to place, according as they were made under the lee of a tongue of land or on exposed beaches. In the latter case they are largely made up of sand and more or less of shell debris, often quite coarse, while in sheltered places they are moderately clayey and usually rather dark-tinted, but always visibly calcareous. The dark tint characterizes likewise a wide belt of land surrounding the lake, doubtless indicating its height at some former period. The rapid recession of the lake during late years having laid bare a good deal of its former bottom, a comparison of the older and newer deposits is easily made. The latter are usually of bluish-gray or whitish tint, often showing specks or fragments of shells, also bits of wood, tule, and other organic remains. The more clayey varieties exhibit the tendency to bake quite hard on the surface in the dry season, while remaining soft and almost "boggy" beneath that crust; hence they are sometimes designated as "dry bog" soils, a term which, however, more properly belongs to another class, presently to be noticed.

The following tables show the composition of two of these lake shore soils, one of which (No. 77, of the heavier type) has also been subjected to mechanical analysis (see reports for 1879, page 27, and report for 1888–89, on "Waters and Water Supply," page 49). Alongside are placed also the analyses of four other soils, representing the older deposits of the lake on its southern border, westward of Delano Station.

No. 1181. A dark gray soil, feeling somewhat chalky when dry, and crushing between the fingers; shows glistening iridescent scales of shell debris, and also larger fragments of fresh water mussels (*Cyclas, Anodonta, Unio*), and some blackened remnants of wood and of rushes. On wetting the mass darkens considerably, and on kneading becomes fairly plastic; with acid effervesces strongly; with test paper shows strong alkalinity.

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From a point twenty miles west from Pixley, Tulare County; sent by G. A. Smith.

No. 77. This specimen was taken from the reclaimed "swamp and overflowed" land, on the east side of Tulare Lake, in 1878; inclosed by a levee, and lying below the high-water mark of the lake; eighteen months before it was all under water, but at the time of taking the sample the water was half a mile from the levee. The first vegetation that started after it was laid dry was "wild parsley," followed later by wire grass, salt grass, and tule. The surface at the time showed but little indication of alkali. "Grain, however, 'burns up' when hot weather comes, even though the ground be moist. Garden vegetables look well until blooming time, and then die."

When sampling the soil at the time stated, it was found to be baked quite hard for the first six inches; from that line down to twenty inches, to which depth it was taken, it was "boggy and soft." The soil as received is a somewhat bluish-gray, clayey sediment, containing a good deal of small gravel and shell debris intermixed. Its reaction is alkaline, though not sharply so.

No. 891 is from the higher land on Section 23, Township 25 south, Range 23 east, southeast from Tulare Lake, in Kern County; a region whose surface conformation shows clearly that at one (prehistoric) time it formed part of the bed of the lake, from the south end of which it is now eighteen miles distant. It is a fawn-colored loam, of fine texture, easily tilled. A large artesian well is on the same section.

No. 893 is from low ground on Section 31, same range and township. When dry it is a pale bluish-gray clay, cleaving in angular fragments; very smooth, plastic, and adhesive when wetted; evidently a lagoon deposit formed in quiet back-water.

In both cases the material is apparently the same for three or four feet downward. The samples were sent by Mr. George A. Raymond.

No. 900. Soil, from Section 15, Township 25 south, Range 23 east, near the border of the lake alluvium. Taken to six inches depth, from land that is just outside of the valley of Poso Creek; very mellow on top, but quite damp and coherent at the depth of six inches. A light gray soil, dry lumps not readily crushed between the fingers; when wetted it softens easily and becomes very plastic. Color becomes more yellowish with increase of depth, with more coarse sand. The subsoil at twelve inches cuts like adobe and contains more coarse sand.

No. 903. Subsoil, from the depth of twelve inches, Section 15, Township 25 south, Range 23 east. More coarsely sandy than its surface soil in the same locality; on drying became covered with a saline efflorescence; becomes barely adhesive on wetting. Contains shells of *Planorbis*, and iridescent scales of bivalve shells.

No. 1224. Soil, from Section 11, Township 26 south, Range 23 east, Kern County. A light gray, silty mass, when dry forming lumps not easily crushed between the fingers, and becoming moderately plastic on wetting, without deepening much in color. Evidently a deposit from low ground; without visible shell debris or lime concretions, but effervescing quite strongly with acid. Sent by Hon. John S. Hittell.

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Soils from Tulare Lake Border.

	Modern Shore Soils.		Ancient Alluvium, South Border.				
	No. 1181. Twenty miles west of Pixley. Depth, 12 inches. G. A. Smith.	No. 77. "S.E. corner of Lake." 1878. E. R. Thomason.	No. 891. Depth, 12 inches. S. 23, T. 25 S., R. 23 E. (higher land). Geo. E. Raymond.	No. 893. Depth, 12 inches. S. 31, T. 25 S., R. 23 E. (lower land). Geo. E. Raymond.	No. 900. Soil. Depth, 1 to 6 inches. S. 15, T. 25 S., R. 23 E.	No. 903. Subsoil. Depth, 12 inches. S. 15, T. 25 S., R. 23 E.	No. 1224. Soil. Depth, 12 inches. S. 11, T. 26 S., R. 23 E. John S. Hittell.
Coarse materials>0.5mm	none.	4.10	none.	none.	2.40	2.20	3.00
Fine earth	all.	96.90	all.	all.	97.60	97.80	97.00
Analysis of Fine Earth.							
Insoluble matter	42.25	67.34	54.71	56.92	45.13	63.52	43.07
Soluble silica	19.70 } 61.95		9.84 } 64.55	10.72 } 67.64	22.96 } 68.09	10.51 } 74.03	24.93 } 68.00
Potash (K_2O)	2.02	1.05	2.02	1.66	1.58	.66	1.75
Soda (Na_2O)	2.21	.84	2.73	.54	1.32	1.43	.99
Lime (CaO)	6.92	6.51	2.46	2.96	3.95	7.56	2.77
Magnesia (MgO)	2.98	3.96	2.93	3.12	2.66	2.01	3.04
Br. ox. of manganese (Mn_3O_4)	.08	.04	.03	.04	.04	.02	.06
Peroxide of iron (Fe_2O_3)	6.25	5.05	7.41	6.73	5.06	3.05	6.88
Alumina (Al_2O_3)	5.38	7.97	11.50	10.35	9.21	3.27	10.23
Phosphoric acid (P_2O_5)	.27	.32	.11	.17	.19	.17	.29
Sulphuric acid (SO_3)	.60	.08	.01	.01	.10	.06	.04
Carbonic acid (CO_2)	5.67	4.42	1.87	.93	3.10	5.82	.89
Chlorine (Cl)	.80	not det'd.	not det'd.	not det'd.	not det'd.	not det'd.	not det'd.
Water and organic matter	4.96	3.71	4.34	5.76	4.01	2.05	5.15
	100.09	101.29	99.90	99.93	99.31	100.13	100.09
Less oxygen (*vice* chlorine)	.35	not det'd.	not det'd.	not det'd.	not det'd.	not det'd.	not det'd.
Total	99.74	101.29	99.90	99.93	99.31	100.13	100.09
Humus	1.22	.47	not det'd.	.38	.20	-------	.67
Ash	1.07	2.18	not det'd.	1.03	.31	-------	1.70
Sol. phos. acid	.03	not det'd.	not det'd.	not det'd.	not det'd.	-------	.05
Silica	.92	not det'd.	not det'd.	not det'd.	not det'd.	-------	-------
Hygroscopic moisture (absorbed at 15° C.)	7.25	not det'd.	8.63	10.53	8.33	-------	9.78

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Water-Soluble "Alkali."

	No. 1181.		No. 891.	No. 903.		No. 1224.	
	In 100 of Soil.	In 100 of Soluble Salts.	In 100 of Soil.	In 100 of Soil.	In 100 Parts Soluble Alkali.	In 100 of Soil.	In 100 Parts Soluble Alkali.
Potassium sulphate (K_2So_4)	.23	6.30				.053	22.10
Sodium sulphate (Na_2So_4)	.63	17.23	.64	1.58	75.60		
Sodium chloride (NaCl)	1.32	36.08				.025	10.40
Hydric di-sodic phosphate (Na_2HPO_4)	.03	.75				.060	25.00
Sodium carbonate (Na_2CO_3)	.63	16.90	.16	.42	20.10	.032	13.30
Soluble organic matter	.83	22.74		.09	4.30	.070	29.20
Total	3.66	100.00	.80	2.09	100.00	.240	100.00

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It will be observed that the deposits of the immediate lake shore of the present time are very rich in lime, containing between 6 and 7 per cent; a large proportion of this exists in the shape of minute shell fragments. From 3 to 4 per cent of magnesia is also present. No. 1181 shows an extraordinary amount of the alkalies (potash and soda), and, as might be expected, a part of these is in the water-soluble form of "alkali salts" to the extent of 2.83 per cent, the composition of which is given in the table below that of the soil. It will be noted that nearly one fourth of the soil-extract consists of vegetable matter dissolved in the carbonate of soda. The sender states that a ten-acre patch of wheat was sown on this soil in September, and about half a "stand" came up and was at the time (December, 1889) eighteen inches high. Whether it will progress to maturity in the presence of so much alkali is extremely doubtful.

No. 77 evidently contained a much smaller surplus of alkali salts, and yet, according to the report made, would grow nothing, probably on account of its recent emergence from the lake. Both soils contain (for California) extraordinary supplies of phosphoric acid, as well as of potash and lime, and if properly reclaimed and cultivated should be profusely fertile.

Nos. 891, 893, 900, and 903 belong to the region just outside of what is commonly recognized as lake alluvium, in the artesian belt of northern Kern County, on lower Poso Creek, and its bayous. These soils differ from the recent lake deposits in a very much smaller proportion of lime, at least near the surface; their phosphoric acid percentage is also materially less; they are strikingly deficient in humus, especially as compared with the "black lands" that occupy a corresponding position on the northeastern lake border. The latter deficiency is doubtless due to leaching by the carbonated alkali solutions, which even now circulate in the soils, and whose effect must, in cultivating them, be currently neutralized by the use of land plaster. But apart from this last named deficiency, which can easily be remedied, these soils will compare favorably, so far as their reserve of mineral plant food goes, with the best in the State now under cultivation; both potash and phosphoric acid contents being far above the average, and doubtless very largely in available form.

The subsoil, No. 903, differs markedly from the three soils in its larger proportion of lime and much smaller amount of potash. It may be that it represents an ancient shell bed, such as must of necessity be looked for in this region, rather than the normal subsoil.

No. 1224, while derived from a locality considerably higher up on Poso Creek, still has the same general character as the other ancient lake-border soils, save that it is as rich in phosphates as are the present lake-shore soils; while the analysis of its "soluble alkali" shows that a part of these phosphates, as well as a goodly amount of potash salts, circulate freely in the soil water, and are of course highly available to plant growth. The promise of productiveness in this soil is certainly very high.

Black Lands.—From these soils of the immediate lake border there is a gradual transition to the "black lands" mentioned above as forming a belt eastward of the lake. Similar black soils also accompany a number of the several creeks, or rather "bayous" of the Kaweah, particularly those of the southern part of the delta—Elk Bayou and its branches, Outside Creek, and Tulare River as well. Some of these black lands are naturally sufficiently moist for the culture of vines and fruit trees, but the higher-lying portions require irrigation.

The black-lands belt of the lake border extends to within two miles of Tulare City, a distance of about twenty miles in a direct line from the lake shore of 1883, of which about half is manifestly lake alluvium proper. Southward the black-lands belt is said to reach to and a little beyond

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Tule River; while the southern border-lands are of the character described above as "ancient alluvium" of the lake. To northward the black lands shade off into the sandy loams of the Mussel Slough country, the delta of Kings River at a time when its waters passed direct through Burris, Mussel, and other sloughs into the lake.

The soil of the black lands (No. 1167) is blackish gray, darkening a good deal on wetting; it is essentially a fine silt with but little coarse sand, and an abundance of small, glistening mica scales. Dry lumps crush with some difficulty between the fingers, and on wetting become fairly plastic, so as not to be tillable when wet. It has the reputation of being exceedingly productive, and as artesian water is readily obtained in its lakeward portions, its settlement is rapidly progressing. After being once established, fruit trees seem to do well with little or no irrigation. The analysis of a sample of this soil, taken on the land of Paige & Morton, on Section 8, Township 20 south, Range 24 east, from the surface to the depth of twelve inches, is given below.

Mussel Slough Soils.—It is of interest to compare with this ancient alluvial soil that of the *Mussel Slough region*, referred to above, the remarkable productiveness of which is well known, and which forms a portion of the older delta of Kings River, directly adjacent to the black-lands belt on the north. The sample was taken near Grangeville, Tulare County, and may be considered representative of that and of the Hanford region.

The soil (No. 579) is a fine sandy loam, of a dark drab color, glistening with mica scales. Dry lumps crush easily between the fingers; on wetting the color deepens but little, and on kneading the mass becomes but slightly plastic, so that land is readily tillable soon after a rain. Nearly the whole of it will pass through the standard sieve.

	No. 579. Soil, 12 inches. Mussel Slough Region, near Grangeville.		No. 1167. Soil, 12 inches. "Black Lands."	
Coarse materials > 0.5mm	none.		10.6	
Fine earth	all.		89.4	
Analysis of Fine Earth.				
Insoluble matter	79.52	82.74	62.43	79.42
Soluble silica	3.22		16.99	
Potash (K_2O)	.70		1.09	
Soda (Na_2O)	.29		.77	
Lime (CaO)	1.25		1.46	
Magnesia (MgO)	1.58		1.44	
Br. ox. of manganese (Mn_3O_4)	.02		.06	
Peroxide of iron (Fe_2O_3)	4.03		4.98	
Alumina (Al_2O_3)	6.58		6.87	
Phosphoric acid (P_2O_5)	.07		.12	
Sulphuric acid (SO_3)	.02		.02	
Carbonic acid (CO_2)				
Water and organic matter	3.05		4.36	
Total	100.33		100.59	
Humus	.64		1.33	
Ash	.58		.36	
Sol. phos. acid			.01	
Silica				
Hygroscopic moisture (absorbed at 15° C.)	3.89		5.38	

According to the analysis, the black-lands soil contains considerably less lime and magnesia than the lake alluvium; also less of potash and phos-

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phoric acid. All these, however, are present in fully adequate proportions for a thrifty and durable soil, and the proportion of humus is large.

The much larger proportion of insoluble matter, most of which is quartz sand (as shown by the small proportion of "soluble silica"), the much smaller proportions of potash, phosphoric acid, and humus, and the lower moisture absorption, at once distinguish the Mussel Slough soils from the black lands, although the common character of abundant mica scales seems also to indicate a common origin, while the mode of formation was doubtless different. Probably the black lands represent the slack-water deposits of the old Kings River delta.

The great depth and perviousness of the Mussel Slough soil, however, compensate for the lower percentages of plant food, since roots can penetrate to great depths in it. Forty-five bushels of wheat have been a common crop on them when fresh, and they are not quickly exhausted. Being very pervious they are easily irrigated by percolation from ditches; their only drawback is the rise of (mostly "white") alkali, that follows careless irrigation and culture.

The Sandy Belt; Plains Soils.—Eastward of the black lands, on which the natural tree growth was either light or absent, we find, first, a low ridge of sandy land, from two to three miles wide, and bearing nearly north and south, originally rather densely wooded, especially near the numerous channels that cross it. Tulare City lies near the eastern edge of this sandy belt, the soils of which correspond to those of the higher plains, and in dry seasons show strikingly the course of ancient channels, now scarcely impressed upon the surface, but filled with a coarse sand, which as a subsoil fails to bring up the moisture from beneath as readily as does the more compact subsoil existing away from these channels. Hence grain will suffer from drought *first* on these ancient creek beds, and appear stunted and yellow, while on the adjacent land it is still green and growing lustily; thus outlining very accurately and strikingly the drainage channels of ancient times.

Salt-Grass Land.—On lower ground within this sandy belt there appear some alkali spots, which increase to eastward and ultimately run together into a tract of "salt-grass" land, about two miles wide, showing the presence of alkali more or less, but rarely to such extent as to offer any serious impediment to cultivation. The soil of this land is of considerably finer texture than that of the Tulare City ridge. As we advance eastward another sandy ridge is crossed, about four miles wide, the soil being quite similar to that near Tulare City, and well settled and cultivated. The following analyses illustrate the composition of these soils:

No. 1159. Sandy soil, from the experiment station tract near Tulare City. Of a buff tint, quite sandy, not assuming any plasticity on wetting and kneading, and capable of tillage at all times. Originally timbered with scattering but large white oaks. Sample taken to the depth of twelve inches; at eighteen to twenty inches the color changes slightly towards yellowish, but texture continues unchanged; at thirty-six to forty inches there underlies a more compact material or hardpan, fairly coherent and of somewhat finer texture, preventing leachiness. Effervesces with acid.

No. 1157. "*Salt-grass*" *soil,* from "Oakland Colony" tract, near Tulare City. This is a fair sample of "salt-grass" land, forming a slight depression below the level of the sandy soil (No. 1159), and here and there showing a slight efflorescence of alkali salts. Most of this land is not timbered, and its natural vegetation is mainly "salt grass" (*Brizopyrum*) and the small star sunflower (*Baeria chrysostoma*). This soil is of finer texture than that of the sandy ridges, into which it shows many grades of transition; is of light gray tint; becomes slightly plastic on wetting and

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kneading; at eighteen to twenty inches is underlaid by a more or less compact, fine-grained silty subsoil, the dry lumps of which can just be crushed between the fingers, and effervesce freely with acids.

No. 1163. Subsoil, from Mr. Burnett's land, three and a half miles south from Tulare City. This land, while outside of the alluvial belt of Elk Bayou, lies considerably lower than the Tulare ridge; the soil resembles that of the "Oakland Colony" tract, and the subsoils of the two appear identical; hence its analysis is placed alongside of No. 1157, of whose subsoil it is doubtless representative.

No. 586. Plains soil, taken midway between Outside Creek and the Sierra foothills, east of Visalia (about Section 35, Township 18 south, Range 26 east). Taken to the depth of twelve inches, there being no visible change for three feet; of a dun color, quite light and sandy, but produces well when irrigated, although it has not been as freely settled as the lands nearer the creeks. The land is quite level, treeless, and despite a rather unpromising appearance, bears a luxuriant growth of wild flowers, testifying of its productive capacity.

Sandy Plains, Tulare County.

	No. 1159. Soil, 12 inches. Experiment Station, Tulare City.	No. 1157. Soil, 12 inches. Oakland Colony, Tulare City.	No. 1163. Subsoil, 18 to 22 inches. Burnett's Land.	No. 586. Soil, 12 inches. East of Outside Creek, northeast from Farmersville.
Coarse materials > 0.5 mm	1.96	3.00	none.	20.30
Fine earth	98.04	97.00	all.	79.70
Analysis of Fine Earth.				
Insoluble matter	72.98	59.88	49.37	73.77
Soluble silica	6.60 } 79.58	13.66 } 73.54	20.72 } 70.09	3.49 } 77.26
Potash (K_2O)	1.20	1.31	1.24	1.22
Soda (Na_2O)	.52	.61	.87	.15
Lime (CaO)	1.86	1.70	3.06	1.17
Magnesia (MgO)	1.81	1.96	2.71	1.75
Br. ox. of manganese (Mn_3O_4)	.08	.05	.04	.03
Peroxide of iron (Fe_2O_3)	6.86	5.80	7.85	5.67
Alumina (Al_2O_3)	5.66	10.11	8.58	7.80
Phosphoric acid (P_2O_5)	.10	.14	.09	.10
Sulphuric acid (SO_3)	.03	.02	.05	.01
Carbonic acid (CO_2)			1.23	
Water and organic matter	2.54	4.66	3.73	4.35
Total	100.24	99.90	99.54	99.51
Humus	.37	1.11		1.14
Ash	.32	.11		.53
Sol. phos. acid		.03		
Silica				
Hygroscopic moisture (absorbed at 15° C.)	2.71	4.82	8.04	4.62

It will be observed that despite their sandy nature, these "plains" soils do not differ widely from some of those of the older alluvium of Tulare Lake, notably from that of the "black lands." All are rich in potash, and contain adequate supplies of lime and phosphoric acid. The salt-grass soil, lying lower than the others, is noticeably richer in most respects, and its alkali will not hurt it. The soil of the station is remarkably poor in humus on the spot sampled, but doubtless this is not the case throughout, judging from the appearance of the land. Its high percentage of soda tells of the vicinity of alkali spots, while the soil No. 586, lying in a particularly well drained region, shows only the ordinary ratio found in upland soils.

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In any case, the great depth to which roots can penetrate in these soils, together with the demonstrably large supply of water-soluble plant food, will render them both thrifty and durable. So far as can be judged from similarity of appearance and mineralogical composition, these soils (especially Nos. 586 and 1159) are fairly representative of the higher portion of the sandy plains generally from Kern to Stanislaus County.

In this connection the composition of the *alkali crust*, forming during the dry season on the low spots in the northwest corner of the experiment station tract, should be considered, and is given in the table below:

	Composition of the Soluble Alkali in 100 Parts.
Potassium sulphate	3.25
Sodium sulphate	20.91
Sodium chloride	12.21
Sodium phosphate	* 1.87
Sodium nitrate	† 16.40
Sodium carbonate	27.02
Ammonium carbonate	‡ 1.27
Organic matter	17.07
Total	100.00

It will be seen that this is a very complex mixture of salts, and that while with its 27 per cent of sodium carbonate it must count as a very "black" alkali, its contents of fertilizing ingredients are rather extraordinary, both in their nature and amount. They include not only potash and phosphoric acid in very notable proportions, but an amount of nitrogen compounds sufficient to impart to the material a considerable commercial value, could it be obtained in large quantities, viz.: $8 72 per ton. That nitrates should be formed in considerable proportion is not surprising in a climate like that of Tulare, since more than 10 per cent of nitrate have been found in alkali as far north as Merced Falls (see appendix to the report for 1886, on "Alkali, Irrigation, and Drainage, in their mutual relations," page 13). But the presence of ammonium carbonate is unexpected, and while possibly accidental in this case (possibly from animal droppings at a former time), it reminds one forcibly of the ammoniacal stench prevalent on some of the "black alkali" tracts of eastern Washington, during the heat of summer. It may be the legitimate and general result of the action of alkali carbonates on the humus of the soil.

While, then, it may be necessary to restrain the excess of alkali in these soils by appropriate means, it would certainly be undesirable to waste, by hasty washing-out, the precious ingredients here gratuitously furnished the farmer by nature, and relieving him for a long time to come of any care for a supply of fertilizers. The first need will be the neutralization of the carbonate of soda by means of gypsum, which will at the same time fix the phosphoric acid, and will in most cases render cultivation feasible without leaching the soil.

Elk Bayou Lands.—Passing this tract we strike the black-lands belt which borders Outside Creek, or Elk Bayou, itself about three miles wide, and well timbered near the stream. This soil is undistinguishable from the black soil of the Tulare Lake border, twelve miles to westward, indicating that both have been formed from the same lake body, which evi-

* 1.12 per cent phosphoric acid.
† 2.69 per cent nitrogen.
‡ .37 per cent nitrogen; total, 3.06 per cent nitrogen.

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dently at that time extended its arms to within a few miles of the Sierra foothills.

Crossing the bayou channels within the black-lands belt, there occurs a notable change. The soil, still apparently in the flood plain of the bayou, becomes whitish; alkali spots appear and finally predominate, leaving only salt grass and salt bushes to occupy the ground for about a mile and a half. The subsoil of this land (which is only a limited area, and not a regular belt along the eastern edge of the bayou) is full of black gravel or bog ore, showing want of drainage; hence, of course, the accumulation of the alkali salts.

Red Lands of the Valley Border.—On the eastern edge of this alkali tract (beyond the old channel of Outside Creek), which shows a "hog-wallow" surface, the land rises gently, and the soil assumes a reddish tinge, indicative of improved drainage; and half a mile farther on we come upon the "red lands" proper, which here skirt the foothills with a width of eight to ten miles. These lands have a gentle slope of ten to twenty feet per mile from the base of the foothills, and appear to be underlaid at a depth of twelve to fifteen feet by water-bearing gravel. The soil is a reddish, more or less sandy loam, changing little in its aspect for several feet, and produces excellent grain crops; its adaptation to fruit culture cannot be doubtful. This red land extends southward to Tule River (Portersville), and doubtless beyond, and also fills the adjacent valleys of the foothills. Northward, it seems to be limited by a line running southward of Farmersville (Lewis Creek?), where a very sandy plain intervenes between Outside Creek and the foothills, south of the Yokol.

The analysis of samples of soil and subsoil of these lands, taken at a point about twelve miles due east from Tulare City, resulted as follows:

Soil and Subsoil from Red Lands.

	No. 1172. Soil, 12 inches.		No. 1173. Subsoil, 12 to 24 inches.	
Coarse materials>0.5mm	10.00		10.00	
Fine earth	90.00		90.00	
Analysis of Fine Earth.				
Insoluble matter	67.74	79.89	68.80	79.96
Soluble silica	12.15		11.16	
Potash (K_2O)	.83		.78	
Soda (Na_2O)	.18		.28	
Lime (CaO)	1.17		1.18	
Magnesia (MgO)	1.22		1.59	
Br. ox. of manganese (Mn_3O_4)	.04		.08	
Peroxide of iron (Fe_2O_3)	5.48		7.82	
Alumina (Al_2O_3)	7.69		5.41	
Phosphoric acid (P_2O_5)	.06		.05	
Sulphuric acid (SO_3)	.01		.01	
Carbonic acid (CO_2)				
Water and organic matter	3.27		2.74	
Total	99.84		99.90	
Humus	.52			
Ash	.16			
Sol. phos. acid	.03			
Silica				
Hygroscopic moisture (absorbed at 15° C.)	3.88		4.06	

It is curious to note that, although this soil and subsoil belong to the valley-border slope and have no outward resemblance to the valley deposits thus far described, yet their composition differs from the latter only in one material point, viz.: the low percentage of phosphoric acid, being less than

half of the average of the valley soils proper. There is also less potash present, but the amount found would be considered ample in any ordinary upland soil, as would also the proportion of lime. Thus far these lands have been chiefly used for grain and have yielded excellent crops, but there can be no doubt that, with so small a proportion of phosphoric acid, they will soon "give out" under the culture; while fruit culture would seem to be their special adaptation, from their friable nature, great depth, and good drainage.

Visalia Section.—A section made east and west through Visalia differs little from the one just described, except in the collocation and width of the several belts. Being nearly in the center of the Kaweah delta, the Visalia district is mostly densely wooded, with a great deal of alluvial soil, some of which is of extraordinary native fertility and requires only the neutralization of some "black alkali," by the use of plaster, to produce double the present crops. An example of the high quality of these alluvial soils is given below in the "wire-grass" soil (No. 585), alongside of which is placed a soil (No. 573), from the crossing of Cross Creek on the Hanford road.

No. 585. "Wire-grass" soil, from the wooded flats two miles west from Visalia; taken to twelve inches depth. This soil is a dark gray or blackish, moderately heavy loam, characterized by a growth of wire grass or small tule (*Scirpus* sp.), and more or less of alkali grass (*Brizopyrum*), with alfilerilla (*Erodium*) and a strong growth of oak. In low places there is a manifestation of alkali, but not enough to cause injury to crops unless of the "black" character. In the higher portions it has proved very productive.

No. 573. Bench soil, from the banks of Cross Creek, on the Visalia and Hanford road. A sandy loam, grayish-dun in color; dry lumps easily crushed between the fingers, falling to pieces when wetted and becoming slightly plastic, the color darkening in token of its humus contents. This is manifestly not a modern alluvial soil, but was formed on low ground at the time the plains were being shaped.

Soils from Visalia Section.

	No. 573. Depth, 8 inches. Bench Soil. Cross Creek.		No. 585. Depth, 12 inches. Wire-grass Soil. Near Visalia.	
Coarse materials>0.5mm	1.50		14.29	
Fine earth	98.50		85.71	
Analysis of Fine Earth.				
Insoluble matter	66.08	69.46	66.47	71.42
Soluble silica	3.38		4.95	
Potash (K_2O)	1.82		1.22	
Soda (Na_2O)	.44		.68	
Lime (CaO)	4.31		3.04	
Magnesia (MgO)	1.59		.09	
Br. ox. of manganese (Mn_3O_4)	.08		.03	
Peroxide of iron (Fe_2O_3)	6.04		5.82	
Alumina (Al_2O_3)	8.69		7.14	
Phosphoric acid (P_2O_5)	.14		.24	
Sulphuric acid (SO_3)	.26		.66	
Carbonic acid (CO_2)	2.53		2.55	
Water and organic matter	4.15		7.09	
Total	99.51		99.98	
Humus	1.00		1.00	
Ash	.74		.84	
Sol. phos. acid				
Silica				
Hygroscopic moisture (absorbed at 15° C.)	8.74		8.53	

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Soluble Alkali of No. 686—Wire-grass Soil.

	In 100 Parts Soil.	In 100 Parts Soluble Alkali.
Potassium sulphate	.122	12.53
Sodium chloride	.024	2.48
Sodium carbonate	.396	40.70
Sodium phosphate	.051	5.19
Magnesium sulphate	.010	1.01
Organic matter	.371	38.09
Total	.974	100.00

The prominent characteristic of both these soils is the large proportion of lime, wherein they resemble the soils of the lake border (see table, page 128). The large amount of potash, particularly in the Cross Creek soil, and the correspondingly heavy proportion of phosphoric acid in the wire-grass land, point in the same direction. The large amount of sulphuric acid in both shows the presence of alkaline sulphates; and analysis showed that nearly one per cent of the wire-grass soil is extracted by water, the composition of which extract (alkali) is given beneath the general analysis.

It appears from this statement that approximately one tenth of the potash and phosphoric acid present are in the water-soluble condition, therefore directly available to plants. This (taking the layer of the soil analyzed, of twelve inches depth) amounts to about three thousand pounds of potash and about eight hundred pounds of phosphoric acid per acre, an amount sufficient, alone, to cover the drain of half a century of heavy cropping, without drawing on the large reserve of the same ingredients, *not* water-soluble, but nevertheless ultimately available, indicated by the general analysis. Practically this soil comes as near to being "inexhaustible" as any within the knowledge of the writer; and it is a striking exemplification of what may be expected of the alkali soils of the San Joaquin Valley when once reclaimed by rational treatment. In the present instance the first condition is the use of land plaster, for it is seen that of the soluble matters over 40 per cent is carbonate of soda, which cannot fail to prove noxious to crops growing on the land; as, in fact, has already been experienced. The use of plaster would not only destroy this noxious salt, but also fix the phosphoric acid so that it cannot be washed into the country drainage.

It will be observed that the Cross Creek soil, so far as it has been examined in the same direction, also shows the presence of a large proportion of soluble potash out of its nearly two per cent contained in the total soil. Being in a position where it could be reached by rains, it has doubtless lost by that process a portion of its soluble plant food, which has passed into the lower lands and there awaits the intelligent labors of the farmer.

A strongly alkaline belt over a mile in width and several miles long exists in the neighborhood of Goshen Station on the Southern Pacific Railroad. It was supposed to be irreclaimable, yet judicious cultivation has rendered cultivation quite successful, although the needful remedy of plastering has not yet been applied. An analysis of the alkali of this tract is given below.

"*Dry Bog Soil.*"—Immediately along and within the foothills there occur, from Tulare to Merced County, limited areas of the so called "dry bog," characterized by a strong growth of long grass and little else, and difficult of cultivation as well as uncertain in production. Examinations as well

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as analysis made of this soil in 1881, show it to be essentially a black adobe very badly drained, so as to be underlaid, at a varying depth, by a gray clay full of black gravel, or bog ore. This subsoil is doubtless essentially the same as the surface soil, only changed by maceration and fermentation of the vegetable matter with the iron solution formed under the influence of stagnant water. The composition of the surface soil is that of a fairly good soil of its kind, and doubtless with good drainage it can be made to produce excellent crops, such as have been made occasionally where, accidentally, the drainage had been improved.

An east-and-west section across the valley, laid through *Fresno City* (which may be considered as occupying the summit of the divide between Kings and San Joaquin Rivers), would not give a correct idea of the soil conformation, because the contact between the soils belonging to the Kings River side and the San Joaquin runs east and west also, and forms an undulating line running about a mile and a half southward of the town, across the valley. The ancient deposits of the Kings River side are represented by the "white-ash" soils of the Central, Washington, and other colonies; while those of the San Joaquin side are reddish sandy loams, contrasting pointedly with the white-ash lands. This distinction is said to be maintained to a greater or less extent nearly to the trough, or edge of the tule belt, to westward; while to eastward of Fresno City both kinds of land run out, as the foothills are approached, into a border belt of brownish clay loam (here also called "adobe"), resembling the soil of the Porterville region, and specially developed along the creeks issuing from the foothills. Interspersed here and there with all these soils are curious low sandy ridges, quite irregularly disposed, popularly known as "sandhills," and differing from the reddish loam in the nature of the sand, which is mainly quartz. Hence these sandhills are rather an unsubstantial foundation for agriculture, will absorb any amount of water without corresponding benefits, and unlike the other soils are quickly exhausted. One is almost tempted to assign to these sandhills a wind-drift origin.

The magnificent results of irrigation in the Fresno region, transforming what seemed an arid waste into a maze of orchards, vineyards, and fields, showing the most luxuriant growth of a great variety of products of the warm-temperate zone, cannot readily be excelled as a cogent illustration of the benefits of irrigation in all its phases. Owing to the porous nature of most of its soils, and the fact that certain portions of the region are underlaid by a more or less compact and impervious calcareous hardpan, it has also served conspicuously, in times past, to illustrate the evils of *over*-irrigation, resulting in the temporary "swamping" of lower-lying lands, and the development of "alkali" where it was never known before, and need not be hereafter under a rational system of drainage. This calcareous hardpan occurs on limited areas here and there, more specially on the white-ash lands; it usually forms a layer eight to twelve inches thick, from eighteen inches to five feet below the surface; sufficiently coherent to be thrown up in sheets of several feet square, but usually crumbling promptly on exposure to the rains of a season. Not so while it remains in the subsoil, when it will often prevent the penetration of roots as well as of water. So that in order to give the roots of trees and vines free access to the moisture and plant-food resources of the subsoil, it becomes necessary to shatter the hardpan stratum where they are to grow. Similar hardpan areas are also found in some of the best lands on Poso Creek, in Kern County, and can be similarly dealt with. This is the more important, as the presence of this hardpan will greatly favor the retention near the surface of any alkali salts that the irrigation water may have brought with it,

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either as an original constituent or as the result of a leaching-out of the subsoil as it rose from below. Hence, the appearance of alkali spots on irrigated tracts originally free from the same will often indicate, and outline pretty accurately, the hardpan layer underneath.

In many respects, therefore, the lands of the Fresno region have a character of their own, so that a station located there could not be readily made to represent the soil conditions of the valley at large. This exceptional character arises, very naturally, from its location between the exits of the two largest rivers of this portion of the Sierra, the Kings and San Joaquin, here only about thirty miles apart at the present time, and at former periods perhaps approaching even more closely. That a dividing ridge or plateau should differ materially in its soil characters from the alluvial areas on either side, is also natural. A full discussion of the soils of the Fresno region will be given hereafter in connection with the description of the viticultural station established there, and the data thus far elicited regarding the grapes and wines, to be published in connection with the report on the viticultural work of 1888 and 1889. In the meantime, the table below will give some idea of the character and composition of the upland soils, and also of the "red adobe," so called, representing the alluvium of the minor streams heading in the foothills. An analysis of a "sandhill" soil is also given:

Fresno Soils.

	No. 570. Alluvial Soil, 12 inches. "Brown Adobe," Eisen Vineyard.		No. 704. Upland Soil, 12 inches. "White Ash," Central Colony.		No. 727. "Sandhill" Soil, 12 inches.	
Coarse materials >0.5mm	20.00		18.20		15.00	
Fine earth	80.00		81.80		85.00	
Analysis of Fine Earth.						
Insoluble matter	76.62	79.49	85.87	88.58	86.58	90.11
Soluble silica	2.87		2.71		3.53	
Potash (K_2O)	.71		.34		.10	
Soda (Na_2O)	.44		.25		.38	
Lime (CaO)	1.77		1.16		.99	
Magnesia (MgO)	2.05		.50		.78	
Br. ox. of manganese (Mn_3O_4)	.04		.03		.06	
Peroxide of iron (Fe_2O_3)	3.73		3.28		3.20	
Alumina (Al_2O_3)	7.99		3.22		3.13	
Phosphoric acid (P_2O_5)	.04		.10		.02	
Sulphuric acid (SO_3)	.07		.12		.04	
Carbonic acid (CO_2)						
Water and organic matter	3.24		1.79		1.53	
Total	99.57		99.37		100.34	
Humus			.60		.43	
Ash			.35		.50	
Sol. phos. acid						
Silica						
Hygroscopic moisture (absorbed at 15° C.)	5.43		2.22		1.21	

It will be noted that while the alluvial soil of the foothill stream (Fancher Creek) resembles closely the "red lands" of the Porterville region in Tulare County, the upland soils differ very materially from any of the soils of the Tulare Plains, above described. The much larger proportion of sand depresses the plant-food percentages shown by the analysis, but the great depth and perviousness of the Fresno soils, permitting the roots to penetrate deeply, and to reach a substratum which nearly always is richer than

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the sandy surface, largely offsets this disadvantage so long as the water table is not allowed to rise too near the surface, limiting sharply the descent of the roots. This influence was strikingly illustrated in the case of the "sandhill" soil, the analysis of which shows it to be extremely poor in everything except lime, both potash and phosphoric acid being far below the ordinary limit of deficiency, and its moisture absorption the lowest of any soil tested. Yet, at a number of points, these sandhills yielded good returns for two or three years, until the extension of the irrigation system brought the water table within four or five feet of the surface, when they "gave out" completely, because the roots were thrown back on a relatively small soil-mass for their support.

In the lower lands of the country to northward of the Fresno plateau, on the San Joaquin and Fresno Rivers, as well as on Cottonwood Creek, we again find soils of a heavier grade and with large supplies of mineral plant food; but the investigation of this portion of the valley has not progressed far enough to justify any broader generalizations at this time.

DESCRIPTION OF THE STATION.

Location of the Station.—The great importance of the experimental study of the alkali question for the San Joaquin Valley, rendered it desirable to locate the station within easy reach of localities where its various phases and natural features could be studied, while preserving the normal character of the plains soils. It therefore seemed expedient to locate it to southward of Kings River, yet not within reach of the influence either of Tulare Lake, or of Kern River with its peculiar water. Hence the offer made by the citizens of Tulare City and County, under the auspices of Tulare Grange, appeared to present the most acceptable features, and after a detailed examination of numerous localities offered as a site, and of the country at large, a twenty-acre tract situated within a mile and a half of Tulare City, and offered by Messrs. B. F. Moore and —. Gould, was finally accepted, with the promise of a subscription of $3,000 for the erection of buildings on the part of the citizens.

The tract, which is nearly square (eight hundred and seventy-one by nine hundred and seventy feet within the inclosure), is practically level, the greatest difference in elevation being only two and a half feet; enough for convenient irrigation. The soil is quite sandy, but has almost throughout, at the depth of twenty-four to thirty inches, a fairly compact subsoil of sandy hardpan, which prevents leachiness. The southeast quarter of the tract is entirely free from alkali, while a body of strongly alkaline soil occupies about one half of the northwest quarter. On the intervening land there are some spots of the same impregnated to a greater or less degree, such as occur scatteringly elsewhere in the region. The tract has borne a few crops of grain heretofore, which failed only on the alkali land of the northwest corner. No oaks were growing on it, but a few trees are just outside of the inclosure.

Improvements thus far Made on the Station Grounds.—A substantial "six-board" fence (redwood posts with one by six Oregon pine planks) was put around the tract in June, 1888. Two gates are provided for, opening respectively from the east and north sides; the east gate is an "Aylward Automatic," placed in a recess provided for the purpose. A light corral for the horses has also been put up on the northwest quarter.

Water Supply.—There being no ditch water regularly available for irrigation, it was determined to utilize, as far as practicable, the abundant supply which can be found by boring to a depth ranging from forty-five

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to sixty feet, and rising to within eleven to thirteen feet of the surface (according to the season) all over the Tulare region. A ten-inch well was sunk near the middle of the tract to the depth of sixty feet. The materials penetrated were reported by the well-borer as follows:

Profile of Well Bored at the Experiment Station, near Tulare City.

		Thickness.	Total Depth.
	2 feet of black sandy loam	2 feet	
	½ foot of hardpan	½ foot	2½ feet.
Surface water ..	9½ feet of sandy loam, light colored	9½ feet	12 feet.
	5 feet of clay	5 feet	17 feet.
Second water....	4 feet of gravel and sand mixed	4 feet	21 feet.
	6 feet of hard clay	6 feet	27 feet.
	14 feet of crumbly hardpan	14 feet	41 feet.
	11 feet of sand	11 feet	52 feet.
	4 feet of clay	4 feet	56 feet.
Third water.....	4 feet of coarse gravel, to clay	4 feet	60 feet.

The well was tubed to fifty-four feet with strong iron pipe, of which the lowest twenty feet was perforated; besides which the pipe was subsequently slotted between twenty and thirty feet from the surface, where the first water was found.

Experience has shown that the most abundant and reliable supply of water is that found at depths ranging from forty-five to sixty feet, in gravel between two beds of clay; and in some of the wells the water level is lowered only a few feet by the most rapid working of a pump delivering seventy gallons per minute. It has been observed that at first the loose gravel at the bottom sometimes obstructs the flow for a time, so that the maximum flow is not immediately established. This proved to be the case in the station well, in which the (triple-action suction) pump, with twenty-nine feet of three-inch pipe and a two-horse power, sucked some air and delivered, after five to seven minutes, only two thirds of the output obtained at first. Since then the well has been used to its full capacity for irrigation during the season, and its output at this date is about seventy gallons per minute with the same pump and power, equivalent to forty-two thousand gallons per working day of ten hours. The flow being equivalent to nearly seven and eight tenths miner's inches of water (four-inch pressure), it would, if continued through the twenty-four hours, be sufficient to irrigate about forty acres of land, according to the allowance made at Riverside; showing that two such wells ought readily to irrigate twenty acres of orange trees, while for fruits needing less water one well may be found sufficient for the same area.

As the well is located near the center, while the highest part is the northeast corner, the water is raised high enough by the pump to be run anywhere through a four-inch pipe (spiral galvanized), which is laid in troughs made of one by four-inch pine boards, twenty feet long, and readily connected at the ends. This mode of distribution was adopted for the present in order to avoid the necessity of boring another well at the highest point, whence the water could have been conveyed in ditches only with heavy loss, by seepage in the sandy soil. During the dry season of 1889, irrigation by ditch water was resorted to once; but if necessary an additional well will be bored in order to remain independent of the ditches. A demonstration of the amount of land that can be irrigated from one of these wells will be of great importance to the Tulare Valley.

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In practicing irrigation a basin is made around each tree in such a manner that the water does not come into immediate contact with the trunk and root-crown; this is necessary to prevent scalding. The basins are connected by shallow ditches opened with the plow. So soon as, afterwards, the soil has dried sufficiently, the ditches and basins are filled up; and this is shortly followed by cultivation to prevent baking or the formation of a surface crust. The latter point is of vital importance, both for the preservation of moisture and as a preventive of the rise of alkali to the surface.

The nature of the water yielded by the wells is illustrated by the analysis given below, of water taken on December 10, 1889. It was intended to take a sample for analysis during the dry season, but owing to unforeseen events this was not done, and the unusual rains of from October to that date have doubtless diluted it somewhat; so that the *quality* rather than the *quantity* of the mineral ingredients contained in it during the irrigation season is indicated by the analysis.*

Analysis of Water from the Bored Well at the San Joaquin Valley Experiment Station, Tulare City.

	Parts in 10,000 of Water.		Parts in 100 of Solid Residue.	Parts in 100 of Soluble Salts.
Potassium sulphate	.026	.475	1.3	5.5
Sodium sulphate	.049		2.5	10.3
Sodium chloride	.066		3.4	13.9
Sodium carbonate	.334		17.0	70.3
Lime carbonate	.893		45.6	
Magnesium carbonate	.258		13.1	
Silica	.239		12.2	
Organic matter	.096		4.9	
Total	1.961		100.0	100.0

Total solid contents, 1.96 parts in 10,000, or 11.5 grains per gallon; permanently soluble, 2.8 grains.

It will be noted that while the total amount of solids found in this water is quite small (eleven and one half grains per gallon), and not quite one fourth of that amount consists of soluble (alkali) salts, yet the nature of these salts is very much more corrosive than is the case in the alkali crust of the spots on the station tract (see above); and should the summer flow of the well prove considerably stronger in mineral contents, the conclusion that gypsum or land plaster should be currently supplied to the lands of the Tulare Basin, in order to neutralize the noxious carbonate, will be greatly strengthened. Be that as it may, this abundant water supply, so readily available to any one at a trifling cost, constitutes an advantage of no mean importance, the more as the full supply derivable from the Kaweah has long been appropriated, and no other large available source of irrigation water is near at hand. The amount of soluble "alkali" in this well water is less than that carried by Kern River, where it issues from the Sierra, and it can therefore be used without stint, and without fear of any material increase of alkali in the soils irrigated.

* Made by Mr. Walter L. Beckh, special student in the agricultural laboratory.

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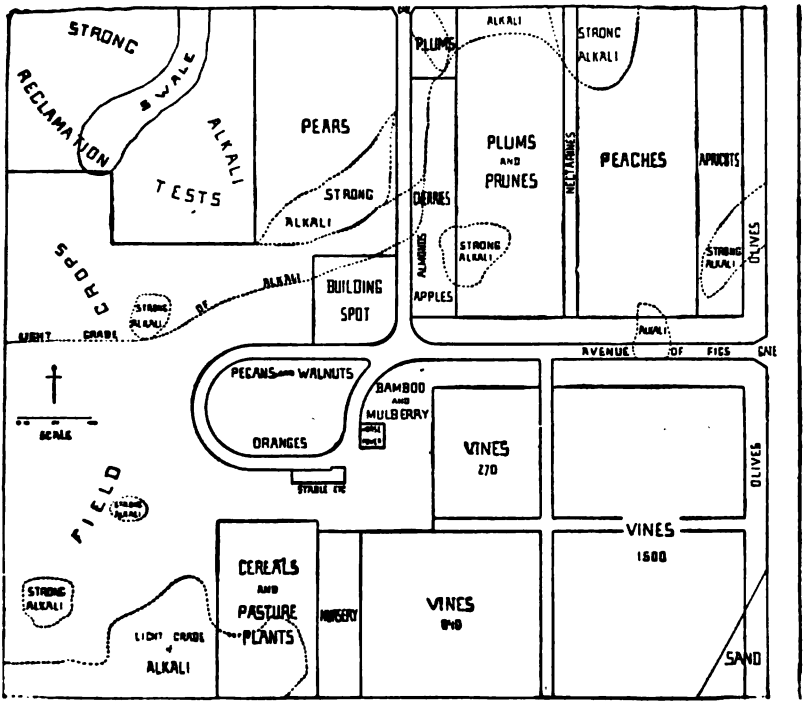

PLAT OF THE EXPERIMENT STATION GROUNDS, SAN JOAQUIN VALLEY STATION.

Buildings.—One of the buildings intended to be put up by subscription among the citizens of Tulare and surrounding country was built in 1888, to wit: a barn and tool house, sixteen by forty-eight feet, a light pine frame, inclosed with redwood "rustic." The cause of the delay in constructing the buildings was the crop failure from drought, which rendered it impossible to collect the subscriptions. The station was nevertheless occupied by the foreman, Mr. Julius Forrer, in December, 1888, he being furnished a cottage (the rent of which was paid by the subscribers to the station fund) situated within easy reach of the station tract. While this delay involved some inconvenience, it did not prevent the planting of the ground, which was done somewhat late in a season that again proved very dry and hot; and hence, with incomplete arrangements for irrigation, did not prove as successful as could have been desired. The auspicious opening of the season of 1889–90, however, with the experience gained in regard to the requirements of the soil, insures, it is hoped, a full stand of trees and vines, and successful cultures of annuals during 1890. The favorable outlook has also encouraged the subscribers to the building fund to come forward, and at this time (end of March) the dwelling house is well advanced, and with favorable weather will be pushed to completion rapidly. The plan adopted is substantially that of the building at the Foothill Station, heretofore described.

The general plan followed in planting the tract will be apparent from an inspection of the plat shown above. The vines have been given the ground practically free from alkali, while the rest of the culture plants have been distributed, in a measure, in accordance with their known ability to flourish in presence of the obnoxious salts. The treatment of the alkali spots that

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became visible last season with a proper dose of plaster will probably obviate all trouble, save in the worst spots, near the northwest corner, where the special experiments of reclamation will be made. A special discussion of this subject is given farther on.

Details of Plantation.—The leading consideration in the arrangement of the various culture plants on the experimental tract has been the presence and absence of alkali. Since, from the natural presumption as well as from previous experience had, the *quality* of wine grapes seems particularly sensitive to the presence of alkali, while orchard fruits appear to suffer only in so far as actual injury is done to the trees themselves by corrosion of the root, crown, or base of the trunk, the higher ground, which is at the same time the lighter soil, was first assigned to the vineyard plantation, after which the orchard and field cultures were assigned such locations as seemed most suitable to them or the general purposes of the station. In this as in the other stations, the unavoidable delays in the preparation for planting have interfered with the full success of the plantings in 1888–9, the more as of the three, the Tulare station is the one requiring the earliest attention. The report of Inspector Klee, given below, shows in detail what has been accomplished thus far, whether in the way of planting or cultural results.

NOTES ON PLANTING AND CULTURAL RESULTS AT THE SAN JOAQUIN STATION.

By Inspector W. G. KLEE.

Orchard.

In the planting of the orchard we aim to determine the adaptation of different kinds of fruit to the soil, especially in reference to alkali. The various classes of fruit, such as peaches, nectarines, and apricots, likely to succeed better grafted on Myrobalan stock than on their own root in soil of alkaline nature, have been fully represented in the spots of such character. Except where the result is very evident, I shall forego details in this matter, it being too soon for definite conclusions. Some five acres of ground are occupied with trees in orchard form.

Apples.—In planting these the alkaline spots were almost totally avoided, soil of this character being considered unfit for apples. The growth of the forty varieties planted has been very fair. It was interrupted by a spell of very hot weather, during which the foliage of no other fruit suffered severely. It is of interest to note that certain varieties imported from Texas, such as Loy, Shannon, Shirley, and Bledsoe, together with the Russian varieties, Alexander and the Astrachans; our California seedlings—Skinner's Seedling, Cook's, or Sonoma Seedling—all more or less characterized by a comparatively thick and large leaf, withstood the hot sun much better than others.

Pears.—Only a few of these failed, but the growth has been short. The collection embraces most of the valuable varieties known in the State, some sixty in all. One of the reasons for their poor growth is the prevalence of the white mite* on the foliage; also the cutting of the leaves by the leaf-cutting bee (*Megachile*), both of which insects are native and abounding in this section. The trees having established themselves this year, will undoubtedly grow well next year; but a timely application of a sulphur wash will be needed to ward off the attack of mites, while the constant cultivation during this season will reduce the leaf-cutting bee to a minimum.

* Apparently a close relation of the "red spider" (*Tetranychus telarius*), but not specifically identified.

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Peaches.—Some sixty varieties were planted on peach root, a portion of which were duplicated on Myrobalan plum stock. The growth of the peaches, especially after the hottest spell, has been fair; the failures being chiefly attributable to alkali in the ground.

Ten varieties of *Nectarines* were planted, with same results as the peaches.

Plums and Prunes.—A collection of some seventy-five varieties of plums and prunes was planted. The majority of these were on Myrobalan stock, either yearling trees or dormant buds; some few duplicated on peach and apricot. The growth of the yearling trees has been fair, but they also suffered from the mites. The plum stock on the whole shows itself better adapted to slightly alkaline ground than the peach.

Apricots.—Of these, twenty varieties on apricot root were planted; the majority duplicated on Myrobalan roots. Considerable failure occurred amongst these.

Almonds have grown pretty well, although suffering from mites. Ten varieties are represented in the collection, all on almond stock.

Cherries.—Only a limited number of cherries were planted—nine varieties in all. The outlook for them does not seem very encouraging so far, but it is premature to draw definite conclusions as to their adaptability.

Figs.—An avenue of thirty-six varieties runs through the center of the grounds, dividing the orchard from the vineyard. Their growth has been uniformly good, the climate evidently agreeing with them. There may be, however, danger to the tender growth from untimely frost. No irrigation was given after the middle of August, as they were still growing very vigorously at that time.

Olives.—A row of olives, including eighteen varieties, is planted on the east side. On this line both figs and olives touch on a wash of sand (a formation quite frequent here) and on the gray colored soil of the plain. Having suffered from the attack of grasshoppers, the olives have merely succeeded in establishing themselves.

Oranges.—Of these only a few varieties of budded trees were planted, the hardiest being chosen. So far they have done very well, the Japanese dwarfs included. Of the sour stock from Florida, quite a number were planted, none of them having had any ball of earth on their roots when received. They have, in spite of this omission, grown well, almost without exception. It is the intention to bud these trees later if they prove hardy.

Orange culture in this section of the county is still in an experimental stage, it being necessary to learn by actual trial what varieties will prove hardy. Further east in the foothills of this county citrus culture is becoming established, and judging from what was seen in that section the outlook appears very encouraging. The region in question, of which Porterville is the best known locality, passed remarkably well through the cold spell of 1887–88, when much damage was done in many parts of the State. The dry summer heat of this region insures the same bright fruit which has made other sections, sufficiently removed from the moist sea air, famous. With this they combine early ripening and a high degree of sweetness.

Walnuts.—All varieties of walnuts suffer much from the heat, being almost defoliated, a notable exception to this being the Santa Barbara soft-shell seedlings, originally raised at Berkeley from seeds obtained from Joseph Sexton, of Goleta. The primary cause of the injury to the leaves seems here also to have been the mite. The conclusion in this direction was strengthened by the condition of several walnut trees in gardens in Tulare City, where they had been sprinkled together with the lawn. All

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these trees were remarkably healthy, and the leaves bright and fresh. Moisture is the enemy of the mite.

The *Pecan* nuts suffered equally with the walnuts.

Miscellaneous Trees.

Camphor Tree.—This tree has stood the heat well, and is making a fair growth, as is also the Strawberry tree (*Arbutus unedo*); but the leaves are smaller than when grown nearer the coast.

The *Kai Apple* (*Aberia Caffra*) seems well adapted to the climate.

Mulberries.—No class of trees has done better, the growth, favored by frequent irrigation, being very good. The collection includes the chief varieties used as food for the silkworm, and also those cultivated for their fruit.

Vineyard.

The portion of the station grounds allotted for vineyard purposes embraces the southeast quarter, and will, when fully planted, have some three thousand vines of a hundred varieties, of which sixty-eight were planted in 1889. Of these, less than half were rooted vines, which have done fairly well; failure being in proportions as given below:

5 per cent or less	7 varieties.
10 per cent or less	2 varieties.
20 per cent or less	6 varieties.
30 per cent or less	4 varieties.
35 per cent or less	3 varieties.
50 per cent or less	1 variety.

Of three varieties no failures are reported. Of the cuttings, the loss has been quite heavy; in every case over 50 per cent, and in many 90 per cent. The failure is partly attributable to the lateness of planting, partly to the slightly alkaline character of the soil, that is unfavorable to rooting.

Grains.

The various varieties were sown too late for so unfavorable and trying a season as the last proved in this section. There was, however, a great difference in the resistance of the various varieties to the drought. The following yielded fertile seed, although most of it badly shriveled. It may be of interest to compare these with the varieties reported from the other stations:

Wheats.—Whittington, Royal, Australian, Pringle's Best, Sonora, Red Russian, Big White Club, Indian Rustproof, Arizona Indian, Yellow Noe, Michigan Mixed, Archer's Prolific, California Spring, Petali, Missoyen, Chile, White Banate, Thuringian, Pringle's Defiance, Egyptian, Volo, Palestine.

Barleys.—Earliest Black, Bluish, Manchurian, Italian, Himalaya.

Grasses and Forage Plants.

As it was too late for the planting of grasses in 1889, it was deferred to the present season, when all the varieties likely to succeed were planted. Under this head must be mentioned several species of salt-bushes adapted to alkaline and saline soils, which in Australia support a vast amount of cattle. Only a few of each kind were planted in alkaline soil, but have all grown well; especially a low, leafy species of *Kochia*, with red blossoms, seems well adapted to the climate. On the strength of their appar-

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ent adaptability, patches sufficiently large for a feeding test will be planted in strongly alkaline soil.

Indian Corn.—At the time of my visit in August the leaves on all the corn were dried to a crisp, and the ears only developed imperfectly. In this respect the station planting shared the fate of all the corn in this region planted on dry land, which is usually not devoted to Indian corn. In moist land corn was not materially affected by the heat.

Sorghums and Sugar Canes.—Of these several kinds were planted and irrigated freely, but did not flourish until the weather grew cooler in September. The portion of the beds touching on alkali ground only produced a very short growth in comparison with the rest.

Bamboos.—Two varieties of this class of plants—Chinese and Japanese—have grown well and seem well suited to the location. It is the intention to increase this collection largely.

ALKALI, ALKALI SOILS, THEIR VALUE AND RECLAMATION.

The frequency with which alkali soils have been referred to in the preceding pages, renders it proper that, in order to avoid a misunderstanding of their practical import, a summary presentation of the subject should be given here. The very name of "alkali" conveys to persons whose only acquaintance with it dates from a dusty trip across the Humboldt Basin of Nevada an idea that its presence is an unmitigated evil, and that only those who cannot do better should venture into alkali-infested districts. To those so impressed it may be needful to mention that, as a rule, the presence of alkali gives evidence of superabundance of mineral plant food in the soil; and that when the excess of saline matters is removed, or rendered innocuous by appropriate processes, such soils are commonly among the most productive and durable to be found in the world.

The fact, amply verified both in California and elsewhere, that repeated surface irrigation tends to bring more of the alkali salts to the surface, to the injury of vegetation, especially when any considerable proportion of carbonate of soda accompanies the more common ingredients (Glauber's and common salt), renders the problem of dealing successfully with alkali one of first importance. It has therefore been under investigation at the Central Experiment Station at Berkeley from the outset, but more especially since, in 1880, the investigations connected with the Tenth Census of the United States have afforded a more extended opportunity for the observation of the broad facts. As these have been set forth at length in former publications, it will suffice to introduce below a summary statement lately made in the form of a bulletin (No. 83), in response to inquiries too numerous to be answered and discussed individually. It should be added that the difficulty is not so much with trees and vines once well established, but with the rooting of cuttings, the planting of young trees and vines having most of their roots near the surface, and with the sprouting of seeds sown superficially, like grain or alfalfa. The latter, especially, is not at all sensitive to alkali when once established; but its seed rots in the ground with the greatest ease when even a small proportion of "black" alkali or carbonate of soda is present; while, when sown with plaster, which neutralizes the carbonate, the difficulty frequently vanishes altogether. The question is undoubtedly a burning one for the Tulare Valley at large; and hence the reclamation of alkali land was among the first things to be considered in the location of a station intended for the benefit of that region.

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The Rise of the Alkali in the San Joaquin Valley.

(Bulletin No. 83.)

The rapid increase of population and settlements in the San Joaquin Valley, and the frequency with which inquiries relative to the nature and treatment of "alkali" come to this station from that section, as well as from other portions of the State, render it expedient to give a summary statement of the main points in the form of a bulletin. A more elaborate treatise on the same subject, originally published in the report for 1880, has been reprinted and can still be sent to those desiring more detailed information.

It is well known that, like all regions having a deficient rainfall and requiring irrigation for successful agriculture, the San Joaquin Valley has (particularly in its upper portions) tracts of land afflicted more or less with "alkali;" that is, showing, during the dry season, a "blooming-out" of soluble salts on the surface of the ground. This phenomenon is the direct and inevitable result of a scanty rainfall in all regions having a naturally productive soil, from which the mineral matters required for the nutrition of plants are being continually set free by the natural processes included under the general term of *weathering;* a decomposition of the minerals contained in the soil, among the products of which are always the soluble salts of the alkalies (potash and soda). The potash salts are, by a peculiar chemical action, mostly retained in the soil and form an important part of the mineral food of plants; while the soda (or sodium) salts, upon which the soil exerts but a very slight retentive action, are, in climates having an abundant rainfall, washed currently into the country drainage and thence into the ocean, whose briny waters testify of the long-maintained accumulative process.

Where the rainfall is scanty, and especially where the showers falling at any one time are so light as to wet the soil only to the depth of a few feet, this current washing-out cannot occur, and the sodium salts necessarily accumulate in the soil, together with those of potash, lime, and magnesia, which are, in the ordinary course of events, wholly or in great part retained by the soil. As a consequence, each time that the soil moisture evaporates between showers it carries with it to the surface, in solution, whatever of soluble alkali salts may have accumulated within the depth to which it penetrated, to be again washed down by the next shower, to such depths as its amount may justify. This process is, in the natural course of events, indefinitely repeated with one and the same quantity of alkali salts, diminished only to the extent to which some heavier shower may wash part of the surface accumulation to the lower ground. Hence, the latter will, as a rule, show a larger proportion of alkali on this account alone; in addition, being naturally richer in the fine and easily decomposable mineral powder carried down and deposited by the streams, the low ground will tend to develop proportionally more alkali than the higher land; and thus we often find such lands, and even the river bottoms, heavily incrusted, when the adjacent uplands are practically free from alkali. But it must not be forgotten that this very fact testifies of the great intrinsic richness of the soil in mineral plant food, and of the highly profitable results sure to follow the effectual reclamation of these low-lying alkali tracts.

The alkali salts vary in composition, but usually consist of three principal ingredients, whose relative proportions vary materially in different regions, and cause corresponding differences in the effects on vegetation, whether natural or cultivated. These three ingredients are, in the usual order of their abundance, common salt (sodium chloride), Glauber's salt

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(sodium sulphate), and salsoda (sodium carbonate). The latter is sometimes present in predominant quantity, and then gives rise to what is popularly known as "black alkali," from the fact that the sodium carbonate forms with the humus of the soil a dark-colored solution, which, on evaporation in mud puddles, leaves black rings on the soil surface. The distinction between the "black alkali" and the "white," consisting mainly of the bland and relatively innocuous Glauber's and common salt, is important, for the effect of carbonate of soda upon vegetation is many times more injurious than that of the former, not only because of its direct corroding effects upon the root-crown when it accumulates near the surface, but also because, as already stated, it dissolves out of the soil that highly important ingredient, humus or vegetable mold, and, moreover, renders clayey soils almost completely untillable. The latter effect is well seen in the low-lying alkali spots, where (even in the sandy lands) the soil, in which the clay accumulates, is so obstinately caked together as to render it extremely difficult to put in the plow, and comes up in heavy intractable clods most difficult to break up. The latter difficulty does not exist in the case of the "white" alkali soils; they till kindly, and the only trouble lies in the accumulation of the salts at the surface, in consequence of evaporation, to such extent as to injure the surface roots and root-crown. Carbonate of soda or "black" alkali is converted into the "white" (*i. e.*, Glauber's salt) by dressings of gypsum or land plaster, and the relief thus afforded is in very many cases all that is needed to insure profitable cultivation.

It is only in exceptionally bad cases that enough of any of these soluble salts to injure the deeper roots exists in the depths of the soil, or within more than one inch of the surface. This surface accumulation is obvious enough to the eye during the dry season; it is well illustrated by the examination of the soluble contents of a soil from Fresno County, given first in the table on page 146. It will be seen that at the surface the alkali contents were nearly four times as great as at any point below.

Aside from the three most prevalent ingredients of the alkali crusts, there are always present a number of others, some of which are of fundamental importance to plant life, and of which their mere presence in the soluble form proves that the soil contains, in a more or less insoluble shape but still accessible to the use of plants, all that it can retain of these useful ingredients. Such are particularly the salts of potash, and soluble phosphates, both of which are very commonly found in the alkali salts from the heavier soils of the San Joaquin Valley; while saltpeter in the form of both potassium and sodium nitrates is common, especially in the "black" alkali districts, and represents a surplus of the most expensive of the fertilizers which the farmer finds it necessary to supply to his soils in order to maintain their productiveness. While it is true that these nitrates are not retained by the soil but may pass away with the drainage, their presence testifies of the intensity of the nitrifying process in the soil under the conditions of the local climate.

Thus, while the presence of an *excess* of alkali salts is an evil, requiring to be abated, yet the above facts, as well as the results of actual trial, prove that alkali soils are eminently worthy of attention and corrective treatment because of their great intrinsic resources in plant food.

The most obvious mode of correcting the condition of alkali soils generally is, clearly, to supplement by artificial means the natural deficiency of drainage *through* the soil, resulting from the scanty rainfall. For, if we once leach out the surplus salts that have accumulated for ages, it will take ages to bring about the same condition of things, and we shall practically have put an end to the "alkali" difficulty.

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But this leaching-out cannot be done by putting water on the surface of the land, unless at the same time its *removal after passing through the soil* is provided for. For it is manifest that if the alkali solution descends no farther than the subsoil and remains there, ready to re-ascend so soon as evaporation at the surface calls for it, we shall have done no good. In fact, the inutility of this mode of procedure has been so thoroughly tested in practice, both in California and in India, as to have shown that it is the reverse of useful and increases instead of diminishing the evil; because the soluble salts thereafter ascend from greater depths than the annual rainfall could have reached, and their sum total is thus materially increased. This is the simple explanation of what is known in the Great Valley as the "rise of the alkali," which is observed in all lands subjected to surface irrigation for some length of time, creating increasing inconvenience and alarm as time progresses.

While under the natural conditions existing in California there is no real cause for alarm so far as the *ultimate* repression of the alkali plague is concerned, and while in the majority of cases judicious cultivation (with the use of gypsum when called for) is capable of preventing any serious damage to crops, yet the present inconvenience and loss resulting from the rise and rapid extension of the alkali-area are sufficient to call for strong measures toward the abatement of the evil. The first condition of such abatement is a general understanding of the nature and causes of the trouble, the more as in many cases the improvement cannot be brought about without such concerted action (and perhaps even the exercise of the right of condemnation and eminent domain) as is required in the case of irrigation works.

UNDERDRAINAGE *is the general and absolute corrective of alkali.* To flood the land until underdrains laid reasonable distances apart shall have run for some time will end the trouble, not only for the time being, but for centuries; provided only that solid beds of the alkali salts do not underlie, as unfortunately seems to be the case in some of the lower lands of the upper Tulare Basin. How to deal with that state of things need not now be discussed, as it is the rare exception.

In the porous soils of the Fresno neighborhood, where until quite lately alkali was unknown, its rise has clearly been brought about by the rise of the water table, resulting from the establishment of high-lying ditches; and its abatement can be brought about by the same means that have been used for lowering the water itself that threatened to swamp the very plains that fifteen years ago showed no moisture at the depth of forty or more feet, but where a few years ago water was within two or three feet of the surface, drowning out both vines and trees. The establishment of drainage ditches has put an end to this danger wherever it has been properly carried out, and with it the alkali trouble can also be terminated by thorough flooding of the surface until the ditches shall have carried away the leachings into the country drainage.

There is, however, in certain regions one difficulty in the way of the success of this operation, namely, the existence of a bed or layer of calcareous hardpan, equally impervious to roots and water. Farmers have already learned that where this hardpan underlies the subsoil at a few feet depth, trees and vines will not flourish unless it is broken through, so as to enable the roots to pass beneath. This "knocking the bottom out" of the holes in which trees are to be planted has already become a well understood operation in the hardpan neighborhoods, the crowbar, or even a charge of powder, being called into requisition. It is noticeable that in such localities the alkali plague comes soonest, and is most persistent, being the

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natural result of the retention of the alkaline water above the hardpan layer, and its re-ascent, with all its salts, so soon as evaporation sets in. The hardpan areas are generally basin-shaped; with the rise of the irrigation water, the latter, with the salts it has leached out of the substrata of the soil, will come in around the edges or through the cracks of the hardpan mass, and, remaining there despite of drains, will bring an increasing amount of alkali to the surface each successive year, until spots of a few square yards grow into many acres, and finally become a serious menace to the welfare of the trees and vines.

The obvious remedy in such cases is to make the drainage ditches deep enough to cut *through* the hardpan, and to knock so many holes into the latter as to facilitate drainage to the necessary extent.

It may be objected that this is too costly; and probably there are cases in which this will be so. It then behooves the owner to consider the choice between a change of location, and the adoption of other crops and repression of the alkali by careful cultivation and the use of gypsum, as set forth in the pamphlet on the subject heretofore published by this department. But the time is not far distant when in California, as well as in Illinois and in the East generally, the laying of underdrains will be considered an excellent investment on any land as valuable as all irrigated land is likely to be; and when that day comes, "alkali" will be at an end on irrigated lands in this State.

In tabular form are given the results of a number of examinations of alkali soils made within the present year, as well as some of earlier date and heretofore published, which illustrate well the variability of the composition of the soluble salts within short distances. Thus, within the ten-acre limits of Miss Austin's place in Central Colony, Fresno, we have two samples of quite different composition; one (No. 1) of the "white," the other of the "black" type, viz.: consisting chiefly of carbonate of soda. In the next three columns we find the alkali of the "white" type, while again, that from the Emigrant Ditch is very "black," and is almost free from Glauber's salt. In Tulare County carbonate of soda is quite generally present in large proportion, doubtless in consequence of the more general prevalence of heavy soils rich in vegetable matter, which promotes the formation of the carbonate. Yet while (according to former observations not recorded here) this is true of the alkali of the Mussel Slough country nearest the streams, the alkali around Hanford is (or was in 1880) almost exclusively of the "white" type. While the water of Tulare Lake, as shown in a former bulletin, is rich in the carbonate, extensive tracts south of the lake, and which were doubtless covered by its waters at a time not very remote (Smyrna neighborhood, in Townships 25 and 26, Range 23), prove to contain mere traces of that substance in their alkali, and do not require the use of gypsum. (See table, pages 146–148.)

It is interesting to compare with each other, respectively, the composition of surface alkali and well water at the experiment station, and on the other hand, the alkali of Tulare Lake water, with that of its ancient and modern alluvium; also, the two groups with each other. In all, the amount of potash salts remains within the units, running from 3.25 to 6.30 per cent. In contrast to this, the sodium carbonate is extremely variable, running from 20 to over 70 per cent. This is readily explained on the basis of the observations recorded in the "Report on Waters and Water Supply," issued by this station some time ago (see pages 51 to 57 of that publication). It is there shown that the other sodium salts, notably the sulphate and chloride, are subject to continual changes under the joint influence of lime carbonate and carbonic acid in varying proportions and

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under varying temperatures; and it is readily intelligible that in the depths of an alluvial deposit the preponderance of carbonic acid should, as in the case of the station well water, give rise to a corresponding preponderance of sodium carbonate, while gypsum is deposited. Hence the importance, if not necessity, of a liberal use of gypsum where such waters are employed in irrigation, in order that under the influence of surface exposure the reverse action may ensue and the noxious carbonate be measurably transformed into bland sulphate. This reverse action has, as will be noted, occurred to a greater or less extent in the surface soils of the lake alluvium; while it became complete farther away, in the Smyrna artesian belt, Kern County, where, as stated above, the alkali is throughout "white."

It is thus apparent that so far as the efficacy of the use of gypsum against alkali is concerned, each region will have to determine for itself whether or not its alkali is of the black or white type; and as this can be generally readily ascertained by a simple inspection of puddles on alkali ground—whether or not tinted by the dissolution of the vegetable mold into an inky liquid, leaving black rings on evaporation—no one need be long in doubt on that point. Wherever the black tint appears, dressings of land plaster, ranging from two hundred to five hundred pounds per acre, will usually effect the change from "black" to "white," after one or two irrigations followed by cultivation; preventing the killing of seeds in the ground as well as the dwindling of seedlings after sprouting, and greatly improving the tillage of the heavier soils. Thereafter, the chief measure toward the prevention of the rise of the salts to the surface is whatever tends to prevent evaporation from the land surface; and therefore particularly the maintenance of deep and thorough tilth, and the avoidance of the formation of any surface crusts. These means, together with a proper choice of crops and mode of culture, will serve to maintain good production in most cases until the radical cure by *drainage alongside of irrigation* shall be justified by the increased value of the land.

Value of Gypsum (Land Plaster) as a Fertilizer.

Since the favorable effects of the use of gypsum on soils tainted with "black alkali" have become known, farmers, as well as others (more particularly those interested in the development of mines of this material), have frequently applied for information as to the value of land plaster as a general fertilizer. To forestall as much as possible the necessity of continuing to answer such queries individually, it is best to present in this place a general statement in the premises.

Since gypsum can supply to the soil only two ingredients taken up by plants as nutrients, it cannot have any direct fertilizing effect save in cases where one or both of these two ingredients—lime and sulphuric acid—are deficient. But of over twelve hundred California soils now in the University collection, probably not over a dozen would be at present benefited by an additional supply of lime; that ingredient being, from climatic causes, almost necessarily abundant in the soils of arid climates. As to sulphuric acid, it has not been found deficient in any soil examined; and from causes parallel to those tending to render lime abundant, it is not likely to be required as a fertilizer anywhere in California within a century. Gypsum is, therefore, *a special fertilizer only*, and is not to be compared to such fundamental fertilizers as the phosphates, the nitrates, and, in their proper place, the potash salts, which serve to replace *directly* what the crops with-

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draw from the soil, and thus to maintain its store of plant food. The cases in which gypsum is found useful may be classed under four heads:

1. It is found efficacious in improving the thriftiness of *all* crops of the "leguminous" tribe; that is, peas, beans, vetches, clovers of all kinds, alfalfa, etc. The exact cause and mode of action in this case is not fully understood; but it is an old and well established fact. At the same time it must not be expected that virgin soils already producing maximum crops will make the use of plaster pay, in going *still* higher. Many such soils already contain all the gypsum that can be useful, and to add more would be "carrying coals to Newcastle."

2. Among the effects known to be produced by gypsum on many, or perhaps most soils, is the setting free, or rendering available, of supplies of *potash* contained in the soil but not in such a form that crops can use it. Probably this is one of the causes of its favorable effect on the legume plants. But as regards California soils, the great majority are remarkable for their high contents of potash, much of which (as the preceding tables and discussions show) is in the soluble and therefore fully available form. Hence, this particular effect of gypsum is likely to be less useful in California and the "arid region" generally than it is in the East, where potash fertilizers are highly important, and soils on an average contain one third to one fifth as much potash as do ours.

3. The utility of gypsum on soils afflicted with "black alkali," or carbonate of soda, has already been sufficiently explained. It is doubtless the most important use for it in California agriculture, at present and for many years to come.

4. Gypsum is of high utility in the preservation of manure, because it absorbs and retains for plant use the carbonate of ammonia so freely given off from barnyards, stalls, and manure piles under all ordinary modes of management. A box of land plaster should be conveniently to hand in every stable for use in the stalls, which it disinfects most effectually without in any manner interfering with the subsequent use of the manure, as is the case with other disinfectants now in common use, in cities especially. It is equally good in other places where offensive exhalations are apt to occur, and its free use would do away with a great deal of the unpleasantness, and some unhealthfulness, now so commonly found about the farmyard and even the dwelling house.

A cheap supply of gypsum is thus of amply sufficient importance to the farmer, here as elsewhere, to render it highly desirable that it should be at command as soon and as cheaply as possible. Its present price, with freight added, is practically prohibitory of its use in agriculture, save in exceptional cases; and it is to be hoped that the abundant deposits of this valuable material, lately discovered in the very region where its use is most urgent, will not remain unused much longer. If those interested knew how greatly the opening up of these mines would benefit them, the delay in doing so would be almost incomprehensible in a country as progressive as California.

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TABLE SHOWING COMPOSITION OF ALKALI SALTS IN SAN JOAQUIN VALLEY—Continued.

	KERN COUNTY.									
	Alkali Crusts from the Smyrna Artesian Belt, Townships 25 and 26, R. 23 E., W.S.W. from Delano, Southern Pacific Railroad.								Sumner.	Kern Island.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	Alkali Crust.	Alkali Crust.
Soluble salts in 100 parts soil										21.15
Potassium sulphate										4.72
Potassium carbonate (saleratus)*										
Sodium nitrate										
Sodium sulphate (Glauber's salt)	little.	moderate.	moderate.	moderate.	large.	little.	little.	little.	19.20	70.61
Sodium chloride (common salt)	large.	moderate.	large.	large.	little.	large.	little.	large.	37.14	4.13
Sodium carbonate (salsoda)										14.82
Sodium phosphate*										
Calcium sulphate (gypsum)	little.	little.	little.	little.	little.	little.	little.	little.	0.96	0.08
Magnesium sulphate (Epsom salt)	little.	little.	little.	little.	little.	little.	little.	little.	18.31	
Organic matter									20.87	
Ammonium carbonate										

* Very generally present, but not always in quantities sufficient for determination.

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APPENDICES.

1. Soil investigation; its methods and results.

2. List of trees and shrubs in the University grounds.

3. List of fruit trees in the station orchards.

4. List of varieties of grapevines represented at the several stations.

5. List of miscellaneous plants in the Garden of Economic Plants.

6. Account of expenditures from the United States Experiment Station Fund, for the year ending June 30, 1889.

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APPENDIX No. I.

SOIL INVESTIGATION; ITS METHODS AND RESULTS.

As the present publication will come into the hands of many who have not seen former reports or the papers published by me in regard to the investigation of soils, and especially their chemical analysis, it seems proper to summarize here, more particularly for perusal by chemists, both the methods adopted in this work and the views and facts upon which it is based. Such explanation is to some extent rendered necessary by the prejudices handed down from the first half of the century, and still rehearsed with sweeping assurance in late publications on agricultural chemistry.

The experiment stations are designed, and are constantly called upon, to furnish information and advice regarding the best agricultural practice within their respective spheres of action, and to resolve existing difficulties and questions by experimentation. But as a matter of fact they do not possess, and have not now the means or even definite prospects to get possession of, the actual facts and conditions surrounding the cases with which they will have to deal. They are placed in the position of a physician who is expected to prescribe for a patient of whose condition and ailments he knows nothing except what public rumor, or the statements of persons ignorant of medical science, may have led him to conjecture.

By what process shall this needful knowledge of climatic and soil conditions be acquired? It is difficult to imagine any other means than the gathering of the facts by competent observers in the field, and their coördination on a uniform plan; in other words, by *agricultural surveys* of the several States, where such surveys have not already been made. And this inevitably involves the systematic and detailed investigation of their soils.

The neglect with which the examination of soils, in regard to their geographical and geological occurrence, and their physical and chemical properties, is commonly treated; the calm assurance with which certain things are asserted of "soils" at large, as though the word had a more definite meaning than that of "rock" or "mineral," is certainly surprising in an age in which even the quarryman resorts to the technical expert and chemist in order to locate his industry and handle his product. The farmer is commonly left to deal with his soil as though the disintegration of the rocks from which it has been formed had wiped out about all practically important differences and reduced it to a definite something, about which one can fearlessly generalize. Because, in the beginnings of agricultural chemistry, incorrect views were put forth, in which the chemical analysis of soils was credited with the value of the assay of an ore, and subsequently this claim was shown to be untenable, the "child has been thrown out with the bath," and chemical soil examination relegated to the superstitions of the past. With it, moreover, the idea that the agricultural expert can render serious and valuable service to the farmer by an examination of his soils *in advance* of the painful and costly experiences of crop failures and mortgages, has also fallen into desuetude; and distinguished authors on agricultural science have gone so far as to go into print with the state-

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ment that they "would rather trust to an old farmer for a correct judgment of a soil than the best (agricultural?) chemist living." If such a *testimonium paupertatis* can be seriously put forth, the science of agriculture must be wofully behind the rest; and one naturally is led to ask by whose most grievous fault this is so.

So far as chemical soil analysis is concerned, the cause is not far to seek; for so soon as experience, and a simple calculation, showed that in most cases the differences between a fresh, fertile soil, and the same soil exhausted by culture, cannot be directly appreciated by the chemists' operations and balance, the usefulness of the analysis of soils long *cultivated and fertilized* was peremptorily relegated to narrow limits. The practical non-existence of virgin soils in western Europe, where nearly all the investigations on these subjects had been carried on, rendered their examination both difficult, and relatively uninteresting to investigators. *As* naturally those of the older States in this country concluded that soil examination was an unfruitful theme to handle, and devoted their attention to the analysis of crops and fertilizers alone; the farmer being taught *ex officio* that the only way for him to settle upon the particular fertilizer required for his soil, was to try, try again, and keep trying. Perhaps this was well enough in its place, although the examination even of cultivated soils will usually reveal many practically important points which may serve to indicate their needs. But when this doctrine was tacitly or expressly extended to *virgin* soils, there was a clear departure from what the record justified; and the urgent demand for some forecast of productiveness and durability of lands intended for settlement in the newer States and Territories, seemed to demand a corresponding effort to obtain such information for the public benefit. It is true that a large mass of data would be required to establish rules for guidance in the interpretation of physical and chemical analyses of virgin soils; it would be necessary to collate them both with the indications of the natural vegetation borne by them and with such experience in cultivation as might be attainable; but it did seem that if the "old farmer" could, upon the basis of his imperfect observation, frequently give good advice in the premises, the agricultural chemist, *with all the farmer's and a great many other data before him*, ought to be able to do a great deal better. But it was also necessary that the observer should be an agricultural chemist, not merely *ex professo*, but should possess personal practical experience in the field, both cultivated and uncultivated, enabling him to translate into practice whatever information might be thus obtainable.

Such, substantially, were the views communicated to the writer by Dr. David Dale Owen, then engaged in the geological and agricultural surveys of Kentucky and Arkansas, in 1855. Dr. Owen did not at that time pretend to be able to interpret correctly the results obtained by him in the investigation of the soils of these States; but he expressed his conviction that with a proper comparison of a sufficient number of data it could and would be done, with great benefit to the farming interest; and he recommended to me the pursuit of similar investigations in the survey of Mississippi, then being begun.

Unfortunately, Dr. Owen's early death prevented him from perfecting his idea; and the numerous analyses made for these surveys under the practiced hand of Dr. Robert Peter, remain as yet without a detailed discussion and classification.

The State of Mississippi afforded me exceptional opportunities for soil studies, on account of the great and strongly contrasted variety of its soils, which happen to be arranged in narrow parallel belts. In crossing these

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the wide and characteristic differences exhibited by them strongly encouraged the hope of definite results from their systematic investigation; and, although the cutting-short of that survey by the civil war first, and afterward by executive interference, withheld from examination a large part of the collections made, the results obtained were sufficiently encouraging to induce a continuation of these studies elsewhere, and in a wider field. The first opportunity was offered in the work of the census of 1880, in connection with which representative soils from all the cotton States were examined and in part analyzed. The ample confirmation of former impressions, thus obtained, led to a systematic presentation of the whole subject in Volumes V and VI of the Census Report, being the portion relating to the production of cotton.

Since then the examination of the soils collected during the progress of the Northern Transcontinental Survey, and of those of California, have so added to the mass of facts that *any one who chooses to discuss them* can satisfy himself of the correctness of Dr. Owen's views, and of the fact that a *properly qualified* agricultural chemist can render the most direct and important services to the farmer, settler, and immigrant, by forecasting both the best adaptation of the lands occupied, the mode of culture, and the improvements and fertilizers that will be first needed when (as now invariably happens) the soil "gives out" under exhaustive culture. This, and not mere glittering generalities, is what an agricultural survey deserving of the name should supply. Mistakes may be made in consequence (usually) of imperfect knowledge or consideration of data; much also still remains to be accomplished in the detailed study of a number of typical cases in order to settle mooted points. But the practical utility even of what has thus far been elicited is so obvious and undeniable, that there remains no excuse for the omission of such work from the State and national surveys. That no greater progress has yet been made must be measurably ascribed to the fact that so few have joined in the prosecution of this kind of research, and that "art is long, life short."

The information desired by the intending settler or land purchaser will usually include the following points:

1. Is the land in question capable of yielding profitable crops without fertilization, or other expensive improvements; and if so,
2. How long is it likely to hold out under ordinary (exhaustive) culture before it will require fertilization?
3. When it does "give out," or seriously slackens its production, what fertilizer will it require first?
4. To what crop is the land, from its (physical and chemical) nature, best adapted?

It is needless to say that these questions, so vitally interesting to settlers or purchasers of land, cannot usually be answered as categorically as can be done in the case of a mineral ore. But it is obvious that in order to reach even a near approximation, it is absolutely essential that the *chemical* as well as the physical nature of the soil be known.

The mode of investigation pursued by me, under the above points of view, and the results so far as they have taken definite shape, are given in the following pages, as concisely as is compatible with the proper presentation of the subject.

While I have preferred to use virgin soils in these investigations wherever possible, yet it is clear that *cultivation without the use of fertilization* from the outside—the "exhaustive" cultivation which is the common practice in the greater part of the United States as yet—cannot bring about any observable

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changes in the soils; this, in fact, is considered so well proven that it has formed the stock argument against the utility of soil analysis. Without, for the present, discussing the exact truth of this allegation, it follows from it that the methods of investigation applicable to virgin soils are likewise valid for soils cultivated but not fertilized. Thus, soil investigation still finds its legitimate field in most of the country lying between the Alleghanies and the Pacific Ocean, where the history of each field is generally still in the memory of persons living; and thus the most valuable direct evidence of the effects of cultivation on natural soils, and of the extent to which soil examination can be useful to practice, is within the easy reach of our experiment stations. It will be their most grievous fault if these advantages, scarcely to be found in any other country in the world, are not utilized by them for the advancement of the science as well as the practice of agriculture.

METHODS OF INVESTIGATION.

Field Survey; Sampling of Soils.—Manifestly, the proper observations in the field, and the correct taking of representative samples when such are wanted, are matters of the first importance, as forming the basis of the whole investigation. There is oftentimes no little difficulty in this preliminary work; it always requires more judgment than a mere "collector" can bring to bear, and oftentimes resident farmers can save the explorer a vast amount of trouble by giving such account of the various kinds of land in his region as his education or talent for observation may comport. Otherwise it will frequently be necessary for the observer to retrace his steps in order to verify observations and to obtain representative specimens from fairly within the limits of the soil-area crossed by him. Since the correct outlining of such areas is among the most important objects to be accomplished by an agricultural survey, and a change in the character of the natural vegetation is usually the most conspicuous mark of changes in soil character; since, moreover, soils are merely modern geological formations, and may or may not be dependent upon the underlying country rock: a knowledge of geology may be considered among the first requisites for a qualified field observer of soils; and another, such knowledge of botany as will enable him to observe and describe correctly the natural vegetation. In settled regions diligent inquiry and observation of the results of cultivation are, of course, indispensable. With all this there should, almost necessarily, be combined a theoretical and practical knowledge of agriculture.

The following directions to field observers, compiled for the field books of the Northern Transcontinental Survey, will convey a succinct idea of the work required:

Directions for Taking Soil Samples and Filling Descriptive Blanks.

First—Consider what are the (usually two or three) soil varieties which, with their intermixtures, make up the cultivable area of the region under examination, and take representative, characteristic specimens of these, and of their subsoils, first of all.

Second—As a rule, and whenever possible, take specimens only from spots that have not been cultivated, nor are otherwise likely to have been changed from their original condition of "virgin soils;" *e. g.*, not from ground frequently trodden over, such as roadsides, cattle-paths, or small pastures, squirrel holes, stumps, or even the foot of trees, or spots that have been washed by rains or streams, so as to have experienced a noticeable change, and not be a fair representative of their kind.

Third—Observe and record carefully the normal vegetation, trees, herbs, grass, etc., of the average land; avoid spots showing unusual growth, whether in kind or quality, as such are likely to have received some animal manure, or other outside addition.

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Fourth—Always take specimens from more than one spot judged to be a fair representative of the soil intended to be examined, as an additional guarantee of a fair average.

Fifth—After selecting a proper spot, pull up the plants growing on it, and scrape off the surface lightly with a sharp tool, to remove half decayed vegetable matter not forming part of the soil as yet. Dig a vertical hole, like a post-hole, at least twenty inches deep. Scrape the sides clean, so as to see *at what depth the change of tint occurs, which marks the downward limit of the surface soil*, and record it. Take at least half a bushel of the earth above this limit, and on a cloth (*not* jute-sack, which is too fibrous), or paper, break it up and mix thoroughly, and fill with it a bag of strong material, size five by eleven inches, or that of an ordinary shot-bag. Before tying it up, place in the part to be tied a folded label of strong paper, on which the number and general designation of the sample is written in *lead pencil*. Tie up with hemp twine, to which attach a strong tag bearing number, designation, date, and locality, in hard black-lead pencil—*not* with "copying pencil."

This specimen will ordinarily constitute the "soil." Should the change of color occur at a less depth than six inches, the fact should be noted, but the specimen taken to that depth nevertheless, since it is the least to which rational culture can be supposed to reach.

In case the difference in the character of a shallow surface soil and its subsoil should be unusually great, as may be the case in swamps or other alluvial lands, or in rocky districts, a separate sample of that surface soil should be taken, besides the one to the depth of six inches.

Specimens of salty or "alkali" soils should, as a rule, be taken only toward the end of the dry season, when they will contain the maximum amount of the injurious ingredients which it may be necessary to neutralize. Samples of such salts as may have effloresced on the surface of the ground should also be secured by scraping off the surface, put up in well-closed packages of thick paper, and sent with the soil.

Sixth—Whatever lies beneath the line of change, or below the minimum depth of six inches, will constitute the "subsoil." But should the change of color occur at a greater depth than twelve inches, the "soil" specimen should nevertheless be taken to the depth of twelve inches *only*, which is the limit of ordinary tillage; then another specimen from that depth down to the line of change, and then the subsoil specimen beneath that line.

The depth down to which the last should be taken will depend on circumstances. It is always necessary to know what constitutes the foundation of a soil, down to the depth of three feet at least, since the question of drainage, resistance to drought, etc., will depend essentially upon the nature of the substratum. But in ordinary cases ten or twelve inches of subsoil will be sufficient for the purposes of examination in the laboratory. The specimen should be taken in other respects precisely like that of the surface soil, while that of the material underlying this "subsoil" may be taken with less exactness, perhaps at some ditch or other easily accessible point, and *should not be broken up* like the other specimens.

A specimen of any rock from which the soil is obviously derived, or with which it is intimately associated, should accompany the subsoil specimen, and may be inclosed in the same bag.

Seventh—All peculiarities of the soil and subsoil, their condition as to drainage, behavior in the wet and dry conditions so far as observable, or ascertainable by inquiry; the presence or absence of ferruginous spots, concretions, or "black gravel" (bog ore), of white calcareous concretions ("white gravel"), as distinguished from mechanically rolled gravel; of "hardpan," calcareous, siliceous, or ferruginous, at such depths as to influence cultivation or the penetration of tap roots; the character of the soil water, whether colored or not by acid organic matter—every circumstance, in fact, that can influence or throw light upon the agricultural quality or adaptation of the land, should be carefully noted and recorded under the proper head.

The information gathered should, as far as possible, *cover all points that would be of interest to the intending settler*, and, while complete, should also be concise.

The blanks on Sheet 1 should in all cases be filled as far as possible, and where the information desired cannot be given, the fact should be stated as "Not ascertainable" or "Not known" in the proper place, with reference, if necessary, to explanatory remarks on Sheet 2, or on an additional slip, to be pinned to Sheet 2; which should be used in case the blank space left should not be sufficient for a full statement of any fact or class of facts. In such case write the word "over" at the bottom of the page, to call attention to such matter.

For samples coming from below a surface soil taken, the blanks on the descriptive sheets need not, of course, be filled farther than down to "Nature of underlying rock." The "designation and numbers of associated samples" should be carefully filled for each sample taken, of whatever nature.

The enumeration of points and subjects in the descriptive blanks are to be considered as suggestive rather than as a complete schedule. Each observer will find, in the field, numerous points of practical interest not foreseen, but which should nevertheless form part of each report.

Frequent examinations of the soil should be made in traveling through a region, in order not to miss points of change, and to obtain an insight into the usual variations of character. Both will, as a rule, be indicated by a change in the character of the natural vegetation, which should therefore be carefully observed and recorded. The taking of representative samples must, from the very nature of the case, very commonly be deferred until an opportunity to observe the characters and changes of soil and vegetation has

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been had. Sometimes this will necessitate turning back, in order to find a representative locality. To obviate this as much as possible, it will often be advisable to collect soil samples not definitely known to be truly representative, and, if afterwards found to be unimportant or misleading, to discard them for better samples.

It is impossible to give any definite measure of the number of samples to be taken on any given area. As a rule, the soils of even extensive agricultural subdivisions may be reduced to a few chief varieties, and their intermixtures in varying proportions. Under ordinary circumstances, it is the former alone that repay the trouble of collection, detailed examination, or analysis. Yet, when certain intermixtures form extensive and well-characterized areas, they should be sampled at least for inspection and verification. Again, where the facilities for transportation are good, samples may with advantage be taken more abundantly than where men or animals have to be loaded down with them. In the case of large districts supposed to be covered by substantially the same soil, it is nevertheless desirable to take several samples, at intervals of several miles, in order to substantiate the impression. In case of difficult transportation, it may be desirable to diminish the usual quantity of each sample, rather than to be compelled to omit important ones altogether. The weight and inconvenience may also be materially diminished by drying each sample as soon as possible after taking, but this should always be done with proper precautions against the introduction of accidental impurities, especially in case the drying is effected by the camp fire. In the latter case it should only be done in closed bags, and even then with precautions against the contact with ashes, salt, etc., and should the bag accidentally become charred, the portion nearest to the charred part should be rejected when placing the sample into a new bag.

Wet soil samples should not be packed or shipped in boxes, as the bags may be destroyed by mold in transmission, and the samples thus be lost. Should circumstances render it necessary to ship or store wet samples, the boxes should be perforated with holes; in case of storage, jute sacks will afford a convenient receptacle, but they should not have contained anything that if communicated to the soils might give rise to errors.

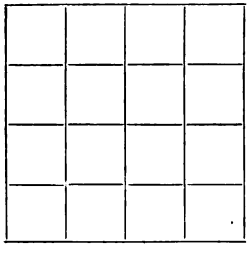
If unable at the time to determine the species of the characteristic plants of any soil, put specimens into a soil bag and tie in with the tag of the soil sample corresponding.

Ship soil samples as often as possible, as they are heavy to carry. Transmit by mail the descriptive sheets referring to each shipment as made, keeping a copy of each in the field book. Mark with a cross in the upper left-hand corner of Sheet 1 any soil sample, the examination of which (whether on account of wide prevalence or of especial fertility or other advantages) you consider of especial importance.

Descriptive Blank.

To be filled by the observer and transmitted by mail.

Sheet 1.



Date: 18—.

Number

Designation of sample:

Designation and numbers of associated samples:

State or territory:

County or district:

Locality: ¼ of ¼ sec. T. R.

Waters of Creek River.

Near

Depth taken: to inches.

Record of obss. in taking sample (see instructions):

Nature of underlying rock:

Geological horizon of same:

Depth under surface:

Does this rock, or any other observed, obviously contribute to the formation of the soil:

Well water, or water table, at what depth:

Nature of water:

Is "alkali" visible on surface, or otherwise known to prevail:

Forest, "openings," or treeless—trees of what species:

Surface bare or sod-covered—what grasses or other herbaceous plants:

What shrubs—sagebrush, greasewood, or others:

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Sheet 2.

Elevation, and general statements regarding surface conformation or "lay" of the land, its relation to watercourses, flood-plain, second bottom, mesa, plateau, rolling uplands, hills, or mountains; whether steep or gentle slopes, their sides capable or not of cultivation, or available as pastures, how high up; soil susceptible or not of gullying or washing in the rainy season, and effect of such washing on the low lands. Width of valleys, their surface level or sloping. Do streams run in deep channels, and through the season? Have artesian wells been tried; with what success, what depths, and what is the quality of water? Has tree planting been tried to any extent? General fitness of land for cultivation or grazing, experience had, present practice and productions. Irrigation, practiced or not, readily feasible or not. Extent of country considered similar to sample; popular designation of country, and of kind of soil. By whom and to what extent is the country settled, etc. Prominent peculiarities of seasons, rainfall, local or general winds, temperature, etc.

What other samples representing substantially the same kind of soil and country have been taken? Give reference by date and number of soil. Add such remarks relative to differences or coincidences as may be of service in connecting the observations.

What other kinds of soil occur within the same general region of country? Give reference by designation, name, and date.

It is not to be expected that the information accompanying the soil samples will always be as complete or cover all the points called for in the above instructions save in the case of experienced observers. The latter will have little difficulty in filling such blanks to a satisfactory degree; and intelligent farmers will often, using their own language in a brief letter, give an equally full account; they do not as a rule take kindly to the filling of blanks.

EXAMINATION IN THE LABORATORY.

With unlimited time and working force at command, it would be very desirable to push the examination of the soil samples into considerable detail in many directions. The determination of the water-holding and capillary power, the chemical effect of fertilizers, and many other data, would, from a theoretical standpoint, be of great interest, and would doubtless in many cases lead to important practical results. But the necessity usually existing in public surveys, of restricting the work to the minimum necessary for practical purposes, imposes limitations and generally compels the selection of the most needful only for the general work, both in physical and chemical examination. It should, therefore, be distinctly understood that in the methods of work hereinafter recorded I have aimed essentially *to do first what is needful for practical purposes*, under the restrictions as to time and means usually imposed in carrying out a public work; oftentimes intentionally sacrificing the greatest possible accuracy of demonstrations to that consideration, where such accuracy is not essential to the attainment of the necessary insight. However unpalatable to the scientific investigator these restrictions may be, it does not follow that they are incompatible with the elimination of scientifically important results and principles. In so wide a field, as yet so little cultivated, a multitude of approximations is likely to lead to more important results than would a small number of very elaborate investigations, for which as yet we lack the leading principles.

Physical Soil Examination.

Preliminary Observations.—A practiced hand—such as that of the "old farmer," or of a *practical* agricultural expert—will usually approximate near enough for practical purposes to a correct estimate of the tilling qualities of a soil, *by handling it in both the wet and dry condition.* If the soil has been sampled when reasonably dry, so as not to have been puddled in the operation, the facility with which small, dry lumps of the same

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may be crushed between the forefinger and thumb will afford a good estimate of its behavior toward the harrow or cultivator; the behavior of these lumps when wetted will show the effect of rains on the dry soil, as in some cases they will at once flatten out into a pile of loose crumbs; in others will retain the shape, but soften readily; while in the case of some close, heavy soils, lumps will not only retain the shape but show no ready softening; while in others of the same class (viz., those of strongly calcareous character) the water will cause the same crumbling as in a sandy loam. *Kneading* of the wetted lump will show what will be the results of tillage after rains, and will, from the degree of plasticity assumed, lead to an approximate estimate of the amount of real "clay" present, as well as of the presence or absence of rock fragments, coarse or fine sand, etc.

A rapid washing of the softened soil in a beaker will enable the observer, when necessary, to determine by means of the lens or microscope the *nature of the sand* present; a matter of no mean importance, since a soil whose mechanical analysis might show the same amount of sand consisting of pure quartz or other undecomposable minerals, would be of very different value from the one whose "sand" consists of granite, slate, basalt, or other country rock, from the disintegration of which the soil derives its origin, and which will, by its more rapid decomposition in the cultivated soil, continue to contribute to its resources.

A material *darkening of the tint* of soils when wetted is always an indication of the presence of much humus (except when they are highly tinted with ferric hydrate), enabling the analyst to proportion properly the amount to be employed in the determination of that substance, or to form an estimate of the humus percentage when that determination has to be omitted.

Such a preliminary physical examination can, as a rule, be made and recorded within half an hour, or less, according to the experience of the observer; and for ordinary purposes it is usually all that is required, provided, of course, that the properties of the corresponding subsoil, and, perhaps also that of the deeper layers, be either adequately known or similarly determined.

Quantitative Determinations of Physical Data.—A full *mechanical analysis* of a soil is always an operation requiring much time and attention, even when the automatic mechanical soil-washer described by me in 1873 is used. In the current work of an agricultural survey, it must ordinarily be restricted to critical cases, in which the judgment of the soils' tilling qualities, or means of improving the same, cannot be otherwise settled.

The most obviously needful separation, in all cases, is that into "fine earth" and coarser materials that as yet form no part of the active soil. Just where to place this limit is a matter of discretion. I have made a uniform practice of using a sieve with meshes of .5 mm. aperture for the purpose, thus connecting the sifting process with the coarsest sediment which it is convenient to handle in the mechanical elutriator, viz.: that corresponding to quartz grains of about .5 mm. diameter, or 60 mm. hydraulic value. Perhaps a smaller value might advantageously be chosen, although with finer sieves there is a rapidly increasing difficulty in preventing the retention on the sieve of aggregates of fine earth with the sand. The character of the coarse materials thus separated is of course duly recorded, both as to prevalent size and mineralogical composition. Sometimes a further separation by sieves is desirable.

When heavy clay soils or clay loams are in hand, the sifting process cannot be carried out in the dry way. It then becomes necessary to soften the soil by digestion with distilled water, on the steam bath, until it can

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be diffused so as to pass the sieve; after which the slush of "fine earth" is evaporated to dryness, care being taken to mix in, thoroughly, the crusts that sometimes form on the sides of the evaporating dish.

Even in this preliminary manipulation much depends upon the means used for crushing, and for separating the fine earth from the coarse material, especially as regards the choice of pestles. At first I adopted one made of soft pine or "whitewood," but became satisfied that in very many cases this is inadmissible, as dissolving mechanical aggregates actually maintained in the soil after tillage. The hand, and then a soft rubber pestle, gently used, form the least objectionable appliances.

When, after this, a complete mechanical analysis is to be made, I still practice, and recommend for the use of the experiment stations, the mechanical soil-washer described by me, since the only other method that furnishes reliable results—the "beaker" method elaborated and recommended by Osborne—necessitates such prolonged, undivided attention on the part of the operator, and when carried into detail as much as the mechanical soil-washer readily permits, takes so much time, as to restrict its use in a very undesirable degree. While I agree with Osborne, that it is not usually necessary or desirable to boil the soils for disintegration as long as originally suggested by me—twenty-four hours—I dissent emphatically from his proposition to substitute "pestling" for boiling in all cases. No delicacy of touch can prevent the crushing and disintegration of complex particles loosely cemented, whether by calcic carbonate, ferric hydrate, zeolithic, or other cements, that form proper and important mechanical ingredients of the soil and should not be broken up if the natural conditions are to be conserved. The pestling of the Mississippi Valley "loess," for example, would produce a material of totally different qualities from the natural soil; and the same is true of most subsoils containing bog ore ("black gravel"). Boiling for any reasonable length of time does not affect these aggregates materially.

The direct determination of the "*clay*" by precipitation, though troublesome, is certainly indispensable on account of the almost paramount importance of that ingredient. But I cannot agree with Osborne that it is permissible to get around the difficulties surrounding this determination by precipitation with ammonic nitrate and subsequent ignition. We have no adequate data for making allowance for the change of weight by ignition; the "clay" of a mechanical soil-analysis is not kaolin; it not only contains metallic oxides, but much of the impalpable soil zeolites, as well as gelatinous humus; and the determination of these substances would have to precede or accompany any attempt to calculate its water of hydration according to a chemical proportion.

The chemical analysis of a number of sets of sediments, representing typical soils, according to the precedent of Loughridge (Am. Jour. Sci., Jan., 1874, p. 18; Proc. A. A. A. S., 1873, p. 80), would be extremely instructive, and will be made at this station as soon as time shall permit. We will thus gain an approximate insight into the degree of coarseness of grain that will ordinarily preclude the material participation of rock debris in the nutrition of plants.

Determination of Relations to Water.—Of these the one that can readily be measured in all cases without an excessive expenditure of time, and which affords a very important insight into the behavior of soils under the influence of atmospheric extremes, is that of *moisture absorption*. Where the hygroscopic condition of the air varies but little, and especially where its degree of saturation is usually high, this factor, though always important, is not as vital as is the case in the arid regions, where it may within

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twenty-four hours range all the way from 30 to 95 per cent, usually with a corresponding variation of temperature in the reverse direction. It has been held by some that the absorption of aqueous vapor by the soil is of little or no consequence to plants, and this conclusion has received a pretended confirmation from ill devised and valueless experiments on the wilting of pot plants. A brief experience of a California "norther" following a spring shower would quickly dissipate such conclusions, for it would be seen that the injury done to grain, other things being equal, follows very obviously the greater or less moisture-retentiveness of the soils; the upper roots and the leaves of the grain on light sandy lands being literally cooked by the heat before any injury is apparent on the heavier and more retentive soils, provided the latter be in good tilth. It is *a priori* abundantly obvious that the elevation of temperature at least must be materially delayed by the evaporation of a larger amount of water, even if no direct benefit were derived by the plant from the moisture in the soil. The "old farmer's" designation of certain soils as "droughty," is *by observation* reduced distinctly to mean *soils of low absorptive power.*

The determination of this factor cannot be properly made in any other way than in a saturated atmosphere, and in a stationary or slightly rising temperature. "Air-dried soil" is an expression devoid of definite meaning for this purpose. As I have elsewhere shown, the amount of vapor absorbed varies very little in a saturated atmosphere, between the limits of 10 and 20 degrees Centigrade. There is therefore little practical difficulty in obtaining concordant and comparable results, *provided complete saturation is fully provided for.* A paraffine bath heated to 200 degrees Centigrade serves for drying the moist soil, of which it is convenient to use about twenty grammes for this purpose.

Extended comparisons with actual practice prove that whenever the moisture-coefficient thus obtained falls below 2 per cent, the soil falls within the limits of what is practically called "droughty;" when below 1.5 per cent, very badly so.

"Sandy loams" have coefficients from 2.5 to 4.5 per cent; between 4.5 and 7.5 per cent lie the substantial clay loams, still of easy tillage and designated as "warm." From 7.5 to 10 per cent and up to 12 per cent is the usual range of "clay soils," such as prairie soils, adobe, etc. These figures are based on the proviso that there shall be no *unusual* proportions of either humus or finely divided ferric hydrate in the soils; when these are present the moisture absorption is profoundly modified and gives no clew to the tilling qualities of the soil. Coefficients as high as 20 per cent or more may in that case be observed.

The "*water-holding power*" of soils does not seem to offer sufficient practical interest to make it a part of an ordinary soil examination, largely because of the similarity of the effects of "fine silt" and "clay." The *capillary coefficients*, on the contrary, would in many cases be of high interest, but the determination requires more time than can usually be given. There is much difficulty in maintaining the soil column unbroken in the case of those having a high rise of capillary water, and months will elapse before the maximum elevation is reached; although in sandy soils that maximum may be obtained within a fraction of a day. This subject is of special importance in connection with the irrigation of alkaline soils, in which the prevention of the "rise of the alkali" may be governed essentially by the capillary rise of which the water is capable within the soil, and the rapidity with which that ascent takes place.

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Chemical Soil-Examination.

The first and a very important step in the ascertainment of the chemical characteristics of a soil is the simple test for *effervescence*, always to be made preferably with hydrochloric acid, and on a sample previously moistened, so that the mere expulsion of air shall not be mistaken for the indication of the presence of carbonate of lime in considerable amounts. The presence or absence of this substance is of such fundamental importance that this test should form part of even the most superficial examination of any soil sample; moreover, it is a necessary preliminary to the ultimate analysis, if such is to be made, as, should no effervescence occur, the trouble of a carbonic acid determination may, in general, be dispensed with, or be replaced by the simple and rapid method of Mondesir.

General Analysis.—The fundamental question of the solvent to be used in extracting the soil to be analyzed, has been under discussion for half a century. The propositions made range all the way from carbonated water to boiling sulphuric acid; some proposing to extract successively with acid of increasing strength, in order to gain an insight into the greater or less solubility of the several ingredients. The latter process may be of interest in some special cases; but it does not, so far as I have been able to see, lead to any conclusions sufficiently definite to justify the enormous amount of labor involved in the examination of a single soil on this plan.

Boiling sulphuric acid is known to bring into solution so much that is of no immediate or prospective use to plants—notably in the decomposition of clay—that its use can only serve to complicate the problem. Its solvent power is certainly greater than that of any acid at the command of vegetation.

Carbonated water, on the contrary, falls very far short of the solvents known to be at the command of plants. The most powerful of these—*oxalic acid*—is of very common occurrence; and, as is well known, it successfully disputes the alkaline bases with nitric and chlorhydric acids. It would seem natural to use this strongest of vegetable acids for the extraction of soils, when it is desired to know what, *at best*, can be extracted by the exsudation of solvents from the root-cells of any plant. But in practice it is found that the difficult solubility of several of its salts interfere so materially with its action in analytical digestions, that it cannot serve as the basis for any uniform series of analyses of varied soils. *If any definite information can be obtained by the extraction of soils with strong acids*, there is no obvious reason why the convenient and well known action of *chlorhydric acid* should not be employed.

As to the concentration to be used, and the temperature to be used in digestion, it is obviously desirable that no unnecessary expenditure of time should occur. If digestion at 100 degrees Centigrade, with acid of convenient strength, will accomplish the objects in view within a reasonable time, it would seem best to adopt this mode, for many reasons that will occur to the practical analyst.

An investigation undertaken at my suggestion by R. H. Loughridge (see the investigation quoted above), of a very generalized soil of the Mississippi Valley, indicates that a digestion for *five days* * with chlorhydric acid of the easily attainable specific gravity of *1.115* (resulting from the fractional steam distillation of acid of *any* strength), produces all the solvent effect desirable, little else than clay being decomposed afterward. I have there-

* *I. e.*, on the general steam bath of the laboratory, which may cool down to 50 degrees Centigrade during the night, but is reheated in the morning.

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fore adopted these conditions in all analyses made under my direction; but it should be added that even considerable deviations from the exact figures adopted do not appear to affect in any serious degree the results, so far as they refer to the mineral plant food of the soil, and therefore to the practical interpretation of the analysis. The addition of a few drops of nitric acid, for the oxidation of soluble organic matter that might otherwise interfere with the analysis, is also without any sensible effect on the final result. But any *ignition* prior to digestion makes a total change, and is entirely inadmissible, as changing fundamentally the natural condition of the soil.

The amount of acid used is ten times that of the soil, or 25 ccm. for the 2.5 grammes of fine earth usually employed in the general analysis. By using so large an excess the variation of strength dependent upon differences in the soluble matter of the soil is reduced to an immaterial quantity. The digestion is carried on in a *porcelain* beaker covered with a watch glass, on the general steam bath of the laboratory.

The subsequent course of the general analysis is like that of any silicate, special attention, however, being given to the conservation of the bulk of solutions within such limits that the solubility of the (usually small, often minute) precipitates shall not materially affect the results. Ferric oxide and alumina are determined in the joint precipitate (formed according to Mitscherlich's method for manganese and magnesia separation) by permanganate titration; the alkalies are separated from magnesia and manganese by the oxalic acid method (sublimated acid only being used), and then from each other by platinum, the latter being weighed in the metallic form.

Special attention is also given to the determination (by boiling with sodic carbonate) of the *silica* set free by the acid digestion. In some cases the same datum has been determined in the raw soil; but the operation is attended with extreme difficulties of manipulation, does not ordinarily seem to lead to any important conclusions, and is advantageously replaced by the determination of humus, etc., by Grandeau's method.

Phosphoric acid is determined in a separate portion (usually a larger quantity than that taken for the general analysis) by the molybdate method, after ignition for the determination of the joint amounts of water of hydration and organic matter. No other method has given such uniformly satisfactory results.

For the determination of *humus* I have uniformly adhered to the method of Grandeau, which alone discriminates accurately between crude, unhumified, and therefore inactive organic matter, and the fully formed, active humus. In the ash of this humus I have, in later times, always determined the *phosphoric acid* and *silica;* while the separation of the bases has been omitted, rather for the sake of economy of time than for any other reason, save perhaps that their status can be approximated from other points of view.

The determination of the *nitrogen* of the soil I have usually omitted, for the reason that in *virgin* soils it seems to be essentially governed by the amount of humus, the determination of which affords an approximation to the resources of the soils in this respect. Still, had the method of Kjeldal been sooner invented, I should have made this determination a usual one, as I intend to make it hereafter.

For the majority of virgin soils the determination of *nitrates*, *actual ammonia*, and of *chlorine*, is unprofitable on account of the constant variability of these substances from day to day. In the case of alkali soils, however, these determinations assume a capital importance.

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Presentation and Interpretation of Soil Analyses.

A convenient and uniform mode of *presenting* soil analyses is certainly important, since comparison is rendered extremely laborious by an indiscriminate arrangement of the items. In the scheme I have definitely adopted for use in this laboratory and in the publications of the station, two points of view are observed. One is that the "insoluble residue" should be the first item to strike the eye, because it gives at a glance a certain insight into the general character of the soil—as sandy or clayey—which it is desirable to have in mind before passing to the inspection of the active ingredients. The other is, that in the arrangement of elements, instead of each one's sweet will, the natural sequence of the electrolytic series should be followed; whereby, of the elements coming under consideration, potassium comes first and carbon last, the rest standing between in the well known order. The adoption of this simple and natural arrangement will obviate an immense amount of trouble and eye work in the extended comparisons, without which soil composition cannot be studied.

Beneath the column of results of the general analysis, but separated so as to involve no misinterpretation, I place the results of the process of Grandeau; and last, the coefficient of absorption of aqueous vapor, which, with the "insoluble residue," goes far to indicate the physical character of the soil.

Interpretation of Analytical Results for Practical Purposes.—In forming a judgment regarding the practical import of the data resulting from a soil analysis, the simple question must be: "WHAT DOES THE COMPARISON OF SUCH DATA WITH ACTUAL AGRICULTURAL PRACTICE TEACH US?"

I have from the beginning of my soil studies—for thirty-five years past—kept this question constantly in view, and have systematically selected soils for detailed examination and analysis with that definite object. In stating hereinafter the conclusions reached, I premise that of course they can be proved only by a discussion of the data, most of which have been published and are accessible to any one desiring to review them. I freely admit that this is a laborious task; but no one who does *not* take the trouble to undertake it, or a corresponding course of investigation, can justly consider himself a competent witness in the premises, either for or against the views here presented. A comprehensive comparative investigation of virgin soils has not been undertaken outside of the United States, nor within them outside of the work conducted by Dr. D. D. Owen and the writer.

The first broad statement that may be made is that *in no case has any natural virgin soil* * *showing high plant-food percentages* (by the analytical processes outlined above) *been found otherwise than highly productive, under favorable physical conditions.* This being true, the practical value of soil analysis is thus far established: that it can teach the settler, *a priori*, that certain soils, new to him and to every one, are a safe investment.

But the reverse is not true, viz., that low plant-food percentages necessarily indicate low productiveness. That it *cannot* be true is evident from the simple fact that heavy clay soils rich in plant food may advantageously be diluted with arid sand, several times over, thereby increasing instead of diminishing their productiveness, *because of improved physical conditions.* This fact is abundantly exemplified in the daily experience and practice

* This maxim does not, therefore, apply to the floor clays of coal beds; nor to a soil that (as the one chosen by Professor Johnson to test the validity of Grandeau's hypothesis) has rested beneath a manure pile for a number of years; nor to a bed of basaltic crumbs such as formed the basis of Dr. E. A. Schneider's objections to soil analysis (Am. Jour. Science).

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of gardeners. In nature it is emphasized by the effects of the washing-down of the poor sandy soils of pine and "black-jack" ridges upon the heavy black prairie soils of the Southwestern States, where the "mahogany" soils so formed are in the highest repute for both productiveness, "safeness," and durability, and are invariably preferred to the black, heavy prairie soils.

Of course there must be a limit to the favorable effects of such dilution, even if effected by means of sand, which renders the soil more readily penetrable by roots. So soon as, instead, the dilution is brought about by inert *clay*, the production of the soils *falls pari passu with the dilution;* a fact of which, again, abundant natural evidence may be found in the Southwest, especially on tertiary territory.

But even in the case of dilution with sand, not only is there a necessary limit beyond which plants cannot make up by greater spread of root for the diminished amount of available plant food existing within a given space; but it is also obvious, and abundantly exemplified in nature, that this limit is materially influenced by the nature of the plant's root system, and especially by its ability to develop abundant root-hair cells. The better provided it is in this latter regard, the greater will be its ability to utilize plant food spread through an extended space in a diluted form.

Quantitative experiments on the limit of dilution for wheat will be made at this station this season, with rich, heavy adobe of part of the station grounds.

A material limiting cause in the premises is the nearness to the surface of either the water table, or of hardpan difficult or impossible to penetrate by the roots. It has repeatedly occurred in California that sandy soils of low plant-food percentages that yielded heavy crops while the water was at the depth of ten or twelve feet, ceased to produce so soon as, by increase of irrigation in the neighborhood, the water rose within five feet or less of the surface. Examination showed that the active root system has thus been confined to less than half of the bulk of soil previously occupied by it in these pervious soils. In clay soils, five feet would have been more than sufficient depth for the same crops, as their roots would not go deeper in any case. In the same region, calcareous hardpan lying at the same depth has, like the water, caused production to languish after a few years; but when it was broken through, after the lapse of a year, vigor was restored.

It is then absolutely indispensable that both the physical character—as to penetrability, absorptive power, etc.—*of a soil should be known, as well as its depths above bedrock, hardpan, or water, before a judgment of its quality, productiveness, and durability can be formed from its chemical composition.* But it is equally obvious that *without* a knowledge of the chemical composition, it is not possible to form such a judgment with "*connaissance de cause.*" Definite information on *both* classes of properties must be before the agricultural expert; and it will be his own fault if from such data he cannot "beat" the old farmer in judging of soils.

High and Low Percentages; Adequacy and Inadequacy.—It need hardly be reiterated that any estimate of what are high or low, adequate or inadequate amounts, as indicated by analysis, can be based only upon *actual comparative observation or experiment of plant growth in virgin soils.* It may be objected even to this, that as we are unable to appreciate by the balance small additions of effective fertilizers to an acre of soil (as *e. g.*, that of a hundred pounds of sodic nitrate), the errors of observation will obscure or obliterate differences actually occurring in natural soils. This objection would be tenable if these errors bore alone upon the *available* portion of the important soil ingredients. As they bear upon the *total* amounts,

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these errors will be inappreciable in any estimate based upon the reasonable assumption, that *as between soils of similar origin the amount of available mineral plant food is proportionate to the totals present;* an assumption which, in a great number of cases of dilution from natural causes, I have found abundantly justified.

Since, however, the presence of one substance in the soil often exerts a material effect upon one or several others, such modifying coexisting conditions must be taken into consideration in forming our judgment. Among these, the presence of a (relatively or absolutely) abundant supply of *lime* seems to be the most common and potent; for the evidence that in presence of much lime smaller percentages of potash and phosphoric acid are adequate for profitable culture than when lime is scarce, is overwhelming. Most potent of all appears to be the coexistence of large supplies of lime and of humus. On the other hand, comparative discussion distinctly shows that the presence of much clay necessitates a larger supply of the active ingredients than is necessary in light or sandy soils; simply, perhaps, for the reason that roots cannot penetrate clay soils as minutely and abundantly as sandy ones.

In the summary statement of conclusions in the premises, given below, these and other modifying conditions require mention, and must be considered jointly with the quantitative results, if correct estimates are to be reached. Such estimates will, as already stated, usually seek to include four chief points:

1. The immediate productive capacity of the soil.
2. The duration of profitable productiveness under exhaustive (non-replacing) culture.
3. The nature of the fertilizer first required when the production slackens.
4. The crops for which it is best adapted.

It is sometimes impossible, in the present state of our knowledge, to go beyond conjectures in some of these questions. But the cases in which much more than this can be done are so numerous (especially after a little experience in cultivation becomes available) as to leave no excuse for the neglect of the study of soils with all the means at our command.

Details of the Analytical Results.—*Insoluble Residue and Soluble Silica.*—The former is, of course, an approximate measure of the greater or less sandiness of the soil—meaning quartz sand or other minerals not easily attacked by acids.

The silica soluble in boiling solution of carbonate of soda affords important insight into the *form* in which several soil ingredients are present; among other points, it frequently proves the very abundant presence of aluminic hydrate, by the disproportion of the two oxides, commonly supposed to exist in combination as clay. It also demonstrates the greater or less abundance of the easily decomposable soil zeolites, which form the reserve of available lime, potash, and magnesia. In soils largely derived from talcose rocks it of course means but little that is of importance. It is noticeable that in the analyses of nearly all soils containing much calcic carbonate, the "soluble silica" is very abundant.

Potash.—Of the three critical mineral soil ingredients—potash, phosphoric acid, and lime—the first seems capable of the greatest variation in percentage amount without materially affecting the productiveness of the soil. The minimum known to me to be found in any productive soil is on the coast of Mississippi, viz.: an average of .05 per cent in the soils of the sea-island cotton plantations. But these soils are remarkable for their sandiness, great depth, and (relatively) high contents of lime and humus.

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Elsewhere, and especially in the (non-calcareous) pine flats and uplands of the South, soils of such low potash percentage are *very* sterile, even when accompanied by fair proportions of phosphoric acid. The ordinary figures for "pine uplands" there range between .150 and .250 per cent; such soils "wear out" within four or five years, but even these seem to be best restored by the use of simple phosphate manures, or by marling; while the commercial potash salts have found little favor. Definite experiments on the subject have been few and unsystematic. In the "oak-and-pine uplands" of Mississippi the potash percentages range from .30 to .45 per cent; in the highly productive and durable "oak uplands" along the Mississippi trough, from .60 to .75 per cent is the rule. Thus, in these uplands the increase of productiveness and durability runs almost exactly parallel to the potash percentage. But in the highly productive and durable "prairie" soils of the same State, the presence of much lime and humus profoundly modifies these relations, and much smaller proportions of potash are common in very productive and durable lands. Hence, it can only be said that as between soils of similar origin and general character, the potash percentage is an important index. So far as experience goes, I consider that *no virgin soil having .50 per cent or over of K_2O will wear out first on that side of its store of mineral plant food; and much less will suffice in the presence of much lime and humus.*

In California the same general rules seem to apply; but owing to the arid climate the potash percentages in our soils are usually so large—up to 1.80 per cent—and moreover so generally accompanied by abundance of lime, that the use of potash salts has in no case proved a paying investment in this State, save after long continued intense culture of small fruit, garden vegetables, etc.

Lime.—The influence of lime upon the physical and chemical character of soils is so potent that the determination of its presence alone amply justifies the use of chemical analysis in the examination of soils for practical purposes. The most cursory observer cannot fail to observe the change that occurs, not only in the natural vegetation, but in the visible prosperity of the population, wherever a calcareous soil-region adjoins a non-calcareous one. That this fact has not been as fully appreciated as it deserves is due simply to the neglect of soil analysis generally, and more specially of that of virgin soils, where these effects are unobscured by the intervention of man.

The Characteristics of Calcareous Soils are not Dependent upon Large Percentages of Calcic Carbonate.—The favorable effects of lime in soils have been additionally obscured by the definition of "calcareous soils" usually given in text-books, which teach that it means "a soil in which carbonate of lime is a predominating or characteristic ingredient, recognizable by effervescence with strong acids." Under this definition calcareous soils are few and far between in this country; whereas, as a matter of fact, the characteristic effects of lime on *vegetation* are produced by the presence of amounts vastly below those causing any visible effervescence, as any moderately attentive observer can verify. Moreover, it is not necessary that *all* the lime shown by analysis should be present in the form of carbonate; for quantitative investigation shows that when largely present in the form of zeolitic compounds, the natural weathering of the soil maintains in it a sufficient amount of calcic carbonate to maintain, also, the calcareous characteristics of the soil; notably the ineffectiveness of dressings of marl, or even of caustic lime.

The Soils of Arid Regions are Necessarily Calcareous.—I have elsewhere shown and discussed the fact that the accumulation of *calcic carbonate* in

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soils is, *a fortiori*, a necessary result of arid climates that permit the accumulation of *alkali* salts in the same. That conversely, *in regions of copious summer rains calcareous soils are exceptional*, and can continue to exist as such only where either calcareous sand or gravel originally intermixed with them continue to supply the lime, or else where the same supply is perpetually renewed from calcareous substrata, of whatever nature. These facts have been abundantly verified by the investigations made by me in Mississippi, Louisiana, and California, as well as by those conducted in the cotton States generally in connection with the tenth census.

Bottom Soils are More Calcareous than Uplands.—It follows from the same premises that the lime contents of "bottom soils" must always be greater than in the soils of the uplands, from the washings of which the former have been formed. Hence, lime vegetation appears in the bottoms of the Atlantic States, even where none is found in the adjacent uplands. *Per contra*, little or no corresponding difference is observable between the upland and lowland growth of the arid regions; the bottom growth is substantially such as, *with sufficient moisture*, will just as well grow in the uplands, as is proved by the results of irrigation. The cause is essentially that uplands and lowlands alike have calcareous soils, *i. e.*, soils containing at least the minimum of lime required to produce lime vegetation.

Subsoils are More Calcareous than Surface Soils.—It also follows that *in all ordinary cases the lime contents of subsoils must be greater than those of the overlying surface soils.* Both of these conclusions are abundantly and completely verified by actual analysis; they might have been foreseen, but there is no definite mention of the fact in any work on agriculture within my knowledge. Yet, if the chemical composition of soils and subsoils is of any importance at all, this is among the most important factors.

Effects of Lime on Humus.—Upon the basis of laboratory experiments with mixtures of lime with various organic substances, it has been held that the presence of lime in soils tends to the rapid eremacausis of humus; and hence, calcareous soils should be poor in the latter substance. The analyses of natural calcareous soils show the contrary state of things; and the intensely black color of the confessedly calcareous "prairie soils" of the West contradicts the above assumption, convincingly, even to the eye of the passer-by. A "gray adobe" or clay soil is invariably poor in lime; a black one, rich in lime as well as in humus. The coal-black tint of calcareo-*humic* soils must not, however, be confounded with the brown one of peaty (*ulmic*) soils; which, however, *become black* when treated with doses of lime sufficient not only for neutralization, but for the continuation of that action which is so well and effectively known in the case of manure piles to favor the humification of the litter. In the arid regions the *only* black soils are highly calcareous ones. *So far as the evidence goes, lime is entitled to be considered the conservator of humus in natural soils.*

"Aufschliessung" by Calcic Carbonate.—It is almost a maxim in chemical geology that the chemical actions which in the laboratory are produced under the influence of strong reagents and high temperature, may and do take place in nature, slowly but not less surely, under the long continued action of weaker agents and lower temperature. As carbonated water will finally decompose the most refractory silicates; as carbonated alkalies in dilute solution will leach the amorphous silica out of hornstone pebbles (see report on the "Geology and Agriculture of Mississippi," 1860, page 19); so calcic carbonate may be expected to perform, in the long run, the same functions as it does in Lawrence Smith's method of silicate "Aufschliessung." We shall expect calcareous soils to be better "aufgeschlossen" for the use of plants than non-calcareous ones, other things being equal; and

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that this is really the case is shown by the high percentages of "soluble silica" (see above) found in such soils, as well as by the general fact mentioned already, viz.: that in calcareous soils much smaller percentages of mineral plant food will suffice for the purposes of crops, under exhaustive culture.

Add to the points enumerated the now well known physical effect of lime in favoring good tilth by the flocculation of clay, and we have an imposing array of advantages to be credited to the abundant presence of lime in agricultural soils.

How Much Lime is Required to Secure These Advantages?—Taking as a guide the evidence of the natural growth as well as that of the results of cultivation, it becomes evident that the amount of lime required to render a soil practically a "calcareous" one, varies greatly according to the nature of the soil. A broad statement may, however, be made, to the effect that *that amount is very much greater in clayey soils than in sandy ones*, and may approximately be said to vary directly as the amount of clay in the soil.

Thus, in the very sandy soils of the sea-island cotton plantations on Mississippi Sound, the presence of as little as .115 per cent of lime gives full sway to lime growth; but in the ill-drained "pine meadows" of the same region, .025 per cent leaves the land sour and sterile. On the other hand, in the heavy clay soil of the central portion of the State, .42 per cent of lime does not suffice to produce a lime vegetation, but .48 per cent, on a similarly heavy soil, shows the characteristic crab-apple and haw of the calcareous prairie soils. Precisely similar observations in Louisiana and California amply confirm the same general conclusion.

Direct comparison of a great number of intermediate soils—loams, from sandy to clayey—confirm the same general rule, for the arid region as well as for that of summer rains. Loams whose moisture-absorption ranges from 4 to 6.5 per cent, require from .20 to .30 per cent of lime to show lime vegetation; the latter takes full possession when the lime percentage rises to .50 per cent, and a farther increase appears to influence the soil more from direct physical action than from chemical causes. I have not seen any advantages to accrue to a soil from an increase of lime beyond 1.5 to 2.0 per cent, except that heavy, clay soils are somewhat lightened by granular carbonate.

These facts, *elicited from actual observation in the field* (cultivated and uncultivated), *and their comparison with the results of analysis*, change materially the proper definition of "calcareous soils" from that given in the text-books of agricultural chemistry. *A priori*, it is not easy to see why any special change should follow the presence of an excess of lime over the amount required to keep the soil constantly drenched with a saturated solution of calcic carbonate in soil water.

Magnesia.—However necessary magnesia may be as an ash-ingredient of plants, it does not seem to exert any important direct action upon the soil as such, so far as comparison of the experience of cultivators and observers of virgin soils can discover. In the soils of the summer-rains region, magnesia generally exceeds lime in its percentage; in moderately calcareous soils (according to the definition given above) it most commonly approximates to lime in its amount. I have never found it to be present in quantities so small as to arouse suspicion of a deficiency; and the experience of mankind in fertilization does not seem to assign it any special importance as an addition to the soil, save for the sake of certain cross-reactions in which it may take part. Soils of very high contents of magnesia are usually poor in other respects, on account of their derivation from talcose or serpentinous rocks. It is noticeable that as a general rule

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the soils of the "magnesian limestone" districts are inferior to those derived from pure limestones; as is well exemplified in northern Alabama and adjoining parts of Tennessee, as well as in Arkansas and Missouri. Just why this should be so is not apparent; but the same holds true of the dolomitic areas of the Spanish peninsula as compared with those in which purer limestones form the country rock.

Manganese.—I have vainly sought to connect this metal with any special soil feature, either intrinsic or connected with its production. While omnipresent, and sometimes quite abundant in the poor "pine woods" soils of the South, whose pine straw contains unusually large proportion of manganese in its ash, its presence, if of any consequence to plants, seems to be amply provided for by nature. I have always determined it in soil analysis because it is there, and for the sake of other determinations must be precipitated.

Iron.—I know of no soil whose contents of ferric oxide would not be more than ample to supply all the needs of vegetation, so far as direct absorption is concerned. Its ascertained percentage rarely falls below 1 per cent, and more commonly ranges from 2 to 5 per cent. A curious fact amply illustrated by analysis is that soils of high ferruginous color do not always contain unusual amounts of the ferric hydrate, the color apparently depending more upon the mode of distribution than on the quantity. This is obvious enough in soils containing bog ore in visible grains; but in many cases it appears to be a semi-crystalline aggregation of the substance around particles of soil and sand that hides the tint.

The almost universal preference accorded to "red" soils as against gray or whitish lands in the same soil region, has given rise to the proposition to render the latter classes equal to the first by the addition of iron in some form, even to the use of magnetite sand and iron scraps. It need hardly be said that the true cause of the preference given to red lands is chiefly that the presence of this color indicates good drainage, whereas in the corresponding "white" lands the iron has usually accumulated in the subsoil in the form of bog ore in consequence of stagnation of water, forming a subsoil in which the process of reduction may recur at any time, and in which (as analysis has shown, and as might have been anticipated) a large proportion of the phosphoric acid of the soil has been accumulated and locked up. A *red* soil is a "*safe*" one, and is usually freed from the need of artificial underdrainage.

That the color imparted by ferric hydrate favors the absorption of heat, is another recommendation of red soils; they are "earlier" than those of white or gray tints. Moreover, as direct determinations show, well-diffused ferric hydrate is powerfully hygroscopic, and adds materially to the retentiveness of soils for moisture; hence, crops on such soils are less liable to suffer from extreme heat than those on less retentive land. My former determinations of this factor in the soils of Mississippi amply illustrate this point, and Californian as well as Hawaiian soils* confirm the conclusion.

Whether, finally, ferric hydrate may not act as a carrier of oxygen in favoring nitrification, is a question for which I have been unable to gather sufficient data. The idea once entertained by myself, that ferruginous soils were apt to be poor in humus, appears from more comprehensive investigations by the method of Grandeau, to be unfounded. But I have not thus far found them especially rich in nitrates either.

A point of practical importance is that, doubtless in consequence of reductive processes, soils very rich in ferric hydrate suffer more promptly

*Some of the latter contain as much as 39.2 per cent of ferric hydrate, corresponding to 27.4 per cent of metallic iron.

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and severely from lack of drainage than similar soils of low iron percentage.

Alumina.—This item in the analysis conveys little information as to the character of a soil, because only a small part of the clay present is usually dissolved by the digestion as practiced in this laboratory. Together with the "soluble silica," however, the figure for alumina often shows very strikingly the degree of decomposition to which the soil has been subject, especially (as noted above) in the presence of much lime. It also serves, sometimes, to indicate the copious presence of aluminic hydrate in some form, when its proportion to the soluble silica admits of no other combination. In such cases, moreover, the loss by ignition is always unusually heavy. When the figure for alumina is very small (2 per cent or less), the indication is that the soil is a very sandy one, of very low hygroscopic power.

Phosphoric Acid.—The conviction that has gradually established itself that the practical values of the several calcic phosphates are not nearly as different as was at first assumed, has materially increased the interest of phosphoric acid determinations in soils, particularly when these are strongly calcareous, and, therefore, according to the well known play of affinities, most of the phosphoric acid present will be in the form of tri-calcic phosphate. There is a good reason why less phosphoric acid in a soil will suffice in soils rich in lime, than in those in which there is no base ready to dispute the possession of the acid with ferric oxide and alumina, which render it relatively insoluble and inert. The very minute amount of phosphates present in the best of soils will render the search of the roots for them very laborious, unless it can be conveyed to them in solution, independently of the acids the roots may exude.

From the discussion of the upland loam soils of the Southwestern States, I have been led to consider .05 per cent of P_2O_5 as the least amount that can be considered adequate for profitable production in their case, and that the percentage should rise to .10 per cent to be satisfactory. But in calcareous, and also in very sandy soils of great depth, less seems a good supply even there, and in California (where nearly all soils are calcareous) the percentage does not very often exceed .10 per cent, even in soils of great present productiveness and durability. The same is true of a good many productive bottom soils of the Southwest, which, however, are always of the calcareous class. Phosphoric acid percentages above .20 occur more rarely in California than in the Southwest; but in the arid region of Texas, and in the basaltic soils of Oregon, Washington, and Montana, .30 per cent and over is not uncommon. In the latter cases the occurrence of apatite crystals in the mother rocks is easily observable, and while such crystals scattered in the soil may be somewhat refractory in dissolution, yet the mechanical and chemical processes of soil formation must have supplied an abundance of finely pulverized mineral ("floats") available for the use of vegetation. These basaltic soils produce extraordinary crops of grain within a very short growing season. It will be interesting to observe how soon their productiveness will decline, and what fertilizer will produce the best effect. I predict that phosphates will *not* be wanted first, but either nitrogen or potash, when the latter is not present in great abundance.

The determination of phosphoric acid soluble in connection with the humus extracted by Grandeau's method is highly interesting; for whether or not that portion may be considered *fully* available, it is certainly very much more so than that which is left undissolved in the same process. The determination has, therefore, been made in all soils analyzed for the past ten years, and has proved very instructive in showing why some soils, with

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very low phosphoric acid percentages, nevertheless did not respond to phosphate fertilizers. But thus far no invariable definite relation between the "soluble P_2O_5," as shown by Grandeau's method, and other conditions, has been elicited by the discussion of the results.

"*Water and organic matter*," or "*loss by ignition*," while not in itself a very instructive item, may become so by collation with the rest of the analytical statement. Representing, as it always does, at least *three* substances—water of hydration of clay and ferric hydrate, etc., crude organic matter, humus proper, and sometimes carbonic acid also—it is usually of very indefinite meaning. The determination of humus reduces its indefiniteness somewhat; but the elimination of another unknown quantity—such as the separate determination of water of hydration—would offer extreme difficulties and usually no adequate return in the way of instructive information. It is, of course, necessary as a check upon the summation of the analysis.

Humus.—The determination of humus by Grandeau's method is of the highest interest, as against the extraction with potassic or sodic hydrates, still sometimes recommended. As the latter solvents do not discriminate between the crude, unhumified vegetable matter and the active humus, it misses the main point of interest.

What degree of uniformity can be predicated of the composition of humus in virgin soils, I have not had time to determine. Even the physical properties of the ammoniacal solutions obtained vary greatly; yet, as in any case humus must be considered the repository and storehouse of the soils' nitrogen supply, its proportion is of high interest.

In the loam (oak) uplands of the cotton States the percentage of humus seems to range usually between .70 and .80 per cent; in the poorer sandy (pine) soils, .40 to .50 per cent; in the black, calcareous, prairie soils, from 1.20 to 2.80 per cent. The determinations made there are not, perhaps, sufficiently numerous to give fair averages.

In California (and in the arid region generally) the humus percentages, as might be foreseen, average somewhat lower; lowest in light loam soils of the high mesas of Southern California, where .30 per cent, and even less, has been found; yet these soils produce well at first, when irrigated. Percentages of .45 to .60 of humus are common in good upland loam soils that are neither very calcareous nor highly ferruginous. The "prairie," or black adobe soils, usually range from 1.20 to 1.80 per cent, a very few as high as 3.00. On the whole, the highly ferruginous soils are remarkable for large amounts of humus; as in the red soils of the foothills and of the Coast Range. In these latter cases, however, the ammoniacal solution is usually quite light-colored, and only becomes dark on evaporation, doubtless by oxidation.

It is pointedly claimed in some of the fruit-growing regions of this State that a too clean cultivation, entirely suppressing the growth of weeds, and thus affording no annual addition of vegetable matter save from the fall of the leaves, tends to injure the production of the orchards. It is readily conceivable that the long, dry, and hot season would tend to cause a very rapid oxidation of the humus in the soil well tilled, amounting to deprivation when only a very little is originally present. From experience had in green manuring, it seems that half of 1 per cent (.50) is the minimum of humus desirable in California, and that when less is originally present an increase should be brought about as soon as possible.

In western Oregon and on Puget Sound, where the summer rainfall is very heavy, humus percentages ranging from 3 to 6 per cent are quite common.

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The item of "*ash*" of the humus extracted by Grandeau's method, is by itself of little significance, as it is sometimes almost wholly silica. Since the latter needs to be eliminated for the determination of phosphoric acid, its weight is easily recorded. Adding it to the amount of phosphoric acid found, the difference from the total ash shows the amount of other inorganic bases and salts present in the ash; but the further analysis of these I ordinarily omit, as adding too much to the general work. In many cases of course such analyses would be extremely desirable and instructive.

Doubtless there will be, even among professional readers of the summary statement here given of the claims of soil investigation in its application to practice, some who, failing to find in it a simple formula for deducing the agricultural value of any soil presented to them, will prefer to continue, as heretofore, to rest on the "*non possumus*" heretofore pronounced by prominent authorities in the premises. To these I would say that so long as they remain content to be mere *assayers* of soils, they might as well let the matter of their valuation rest where mere assayers must leave the value of ores of corresponding complexity, while they remain ignorant of the principles of metallurgy, and cannot prescribe any method of smelting that will extract the metal. *That* is the business of the *metallurgical* expert; and so, in the matter of soils, it will be the *agricultural* expert, and not the mere chemist or the mere farmer, who can properly expound and utilize for practical purposes the results of soil investigation. It is to be hoped that with the progress of the work of agricultural colleges and experiment stations, the class of men who combine both the theory and practice of agriculture will become more numerous.

APPENDIX No. 2.

LIST OF TREES AND SHRUBS IN THE UNIVERSITY GROUNDS.

It should be understood that in making up this collection, the object has been not so much a complete representation of species, as to bring together representative species from such climatic regions as seemed to offer plants of possible practical interest.

In the list the plants that are "half hardy" in the climate of Berkeley are marked "hh;" they require some protection when left in the open air in severe winters. Those requiring to be kept in the greenhouse (cold or warm) in ordinary winters are marked "g." Local wild species growing within the grounds are marked "l."

MAGNOLIACEÆ.

Magnolia grandiflora, Large flowering magnolia.
Magnolia acuminata, Cucumber tree.
Magnolia tripetala, Umbrella tree.
Liriodendron tulipifera, Tulip tree.
Liriodendron integrifolium.

MENISPERMACEÆ.

Menispermum Canadense.

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CAPPARIDEÆ.

Capparis spinosa, var. *inermis*, Caper bush.

BERBERIDEÆ.

Berberis aquifolium, Holly-leaved barberry.
Berberis heteropoda, Edible barberry (from Turkestan).
Berberis Fremontii, Arizonian barberry.
Berberis pinnata, California barberry.
Berberis vulgaris, Common barberry.

ANONACEÆ.

Asimina triloba, Pawpaw.
Anona Cherimoya, Custard apple. hh.

CISTACEÆ.

Cistus ladaniferus.
Cistus albus, White rockrose.

TAMARISCINEÆ.

Fouquiera splendens.

HYPERICACEÆ.

Hypericum ovatum, Shrubby St. John's wort.

STERCULIACEÆ.

Sterculia (*Firmiana*) *platanifolia*.
Sterculia diversifolia.
Mahernia adorata.
Brachychiton acerifolium, Australian flame tree.

MALVACEÆ.

Malva fragrans.
Hibiscus Syriacus, Shrubby althea.
Hibiscus Sinensis, Indian hibiscus.
Lavatera arborea, Tree mallow.
Lavatera assurgentiflora.
Lavatera insularis.
Lavatera venosa.
Abutilon Chinense, Chinese abutilon.
Abutilon vexillatum.

PITTOSPOREÆ.

Pittosporum undulatum.
Pittosporum rubiginosum.
Pittosporum patulum.
Pittosporum eugenioides.
Pittosporum tenuifolium.
Pittosporum crassifolium.
Pittosporum fragrans.
Sollya heterophylla.
Bursaria spinosa.

TERNSTRÖMIACEÆ.

Thea Bohea, Chinese tea plant.
Camellia Japonica, Camellia.
Aristotelia racemosa.

RUTACEÆ.

Xanthoxylon piperitum, Japanese prickly ash.
Ptelea trifoliata, Hop tree.
Triphasia trifoliata, Three-leaved orange.
Citrus Japonica, Japan orange.
Citrus aurantium, Sweet orange.
Citrus vulgaris, Bitter orange.
Citrus Limonum, Lemon.

ANACARDIACEÆ.

Rhus Cotinus, Smoke tree.
Rhus Canadensis, Fragrant sumac.
Rhus venenata, Poison ivy.
Rhus vernicifera, Varnish tree of Japan.
Rhus succedanea, Wax tree of Japan.
Rhus Coriaria, Tanner's sumac.

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Rhus integrifolia, California sumac.
Rhus diversiloba, Poison oak. l.
Lithraea venenosa.
Schinus molle, Pepper tree.
Pistacia Terebinthus, Chian turpentine tree.
Pistacia vera, Pistachio nut.

CELASTRACEÆ.

Euonymus Japonicus.
Euonymus radicans.
Euonymus fimbriatus.

RHAMNEÆ.

Rhamnus Californica. l.
Rhamnus crocea.
Maytenus Chilensis.
Hovenia dulcis.
Ceanothus sorediatus. l.
Dodonaea viscosa.
Aberia Caffra, Kai apple. hh.
Berchemia volubilis, Supple jack.
Colletia ferox.

VITACEÆ.

See list of fruits, trees, and vines.

CORIARIEÆ.

Coriaria myrtifolia.

SAPINDACEÆ.

Æsculus Californica. l.
Alectryon excelsum.
Sapindus Mukorasi, Japanese soapberry tree.
Sapindus marginatus, Arizonian soapberry tree.
Acer saccharinum, Sugar maple.
Acer circinatum, Vine maple.
Acer campestre.
Acer polymorphum, Japanese maple.
Acer macrophyllum, Large-leaved maple.
Negundo aceroides, Box elder.
Negundo Californicum.
Koelreuteria paniculata.
Melianthus major.

MELIACEÆ.

Melia Azedarach, Pride of India, China tree.
Melia Azedarach, var. *umbraculiformis*, Texas umbrella tree.
Melia Azedarach, var. *indica*, Neem tree.

LEGUMINOSÆ.

Robinia pseudacacia, Black locust.
Spartium junceum.
Ulex gigantea, Furze.
Ulex Europaea, Furze.
Coronilla glauca.
Coronilla emerus.
Cytisus Laburnum, Golden chain.
Cytisus Atleanus.
Cytisus proliferus albus.
Cytisus scoparius, Scotch broom.
Cytisus Canariensis, Canary Island broom.
Lupinus Douglasii.
Lupinus Ludovicianus.
Hosackia glabra. l.
Psoralea glandulifera.
Clianthus puniceus, Parrot's bill.
Edwardsia grandiflora.
Edwardsia microphylla.
Virgilia lutea, Yellow wood.
Pueraria Japonica, Japanese starch vine.
Cercis occidentalis, Red bud.
Acacia decurrens, Black wattle.
Acacia dealbata, Silver wattle.
Acacia pycnantha, Golden wattle.
Acacia cyanophylla.
Acacia armata.
Acacia Riceana.

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Acacia verticillata.
Acacia longifolia.
Acacia linearis.
Acacia lineata.
Acacia calamifolia.
Acacia implexa.
Acacia cultriformis.
Acacia celastriformis.
Acacia linifolia.
Acacia arabica. hh.
Acacia Cavenia.
Acacia imbricata.
Acacia melanoxylon, Blackwood.
Acacia salicina.
Acacia floribunda, Sentis.
Acacia leiophylla.
Acacia Greggii, Texan mimosa.
Gymnocladus Canadensis, Kentucky coffee tree.
Gleditschia triacanthos, Honey locust.
Gleditschia triacanthos, var. *inermis,* Thornless honey locust.
Parkinsonia aculeata, Palo verde (Green stick).
Prosopis juliflora, Honey mesquit.
Prosopis pubescens, Screw mesquit.
Ceratonia Siliqua, Carob tree.
Sophora Japonica, Japan dye-wood.
Poinciana regia.

ROSACEÆ.

Rosa rugosa, Japanese rose.
Rosa setigera.
Rosa laevigata, Cherokee rose.
Rosa hybrida, in var.
Rosa indica, in variety.
Rosa sulphurea.
Rosa Banksiæ, in var.
Rosa sempervirens.
Rosa gymnocarpa. l.
Rosa Californica. l.
Rubus vitifolius, California blackberry. l.
Rubus Nutkanus, Thimbleberry. l.
Rubus spectabilis.
Rubus villosus, Eastern blackberry.
Rubus idæus, Raspberry.
Rubus occidentalis, Black-cap raspberry.
Nuttallia cerasiformis.
Prunus Myrobalana, Myrobalan plum.
Prunus Armeniaca, Apricot. (See fruit trees.)
Prunus domestica, Common plum. (See fruit trees.)
Prunus subcordata, Sierra plum.
Prunus Persica, Peach. (See fruit trees.)
Prunus avium, Black heart cherry. (See fruit trees.)
Prunus Cerasus. (See fruit trees.)
Prunus Mahaleb. (See fruit trees.)
Prunus serotina, Bird cherry.
Prunus ilicifolia, Holly-leaved cherry.
Prunus lauro-cerasus, English cherry laurel.
Prunus Lusitanica, Portugal laurel.
Prunus Caroliniana, Carolina cherry laurel.
Prunus emarginata, Dwarf cherry.
Sorbus aucuparia, European mountain ash.
Sorbus domestica.
Amelanchier alnifolia. l.
Raphiolepis ovata.
Pirus communis, Pear. (See fruit trees.)
Pirus malus, Apple. (See fruit trees.)
Pirus Coronaria, Crab-apple. (See fruit trees.)
Pirus Caccata, Siberian crab. (See fruit trees.)
Pirus Japonica, Japanese, or Sand pear. (See fruit trees.)
Peraphyllum ramosissima.
Cydonia Japonica, Japan quince.
Cydonia vulgaris, Common quince. (See fruit trees.)
Crataegus tomentosa.
Crataegus pyracantha, Fire thorn.
Kerria Japonica.
Cotoneaster microphylla.
Heteromeles arbutifolia, California red haw (Photinia). l.

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Eriobotrya Japonica, Japanese medlar, or Loquat.
Spiraea callosa, var. *alba*.
Spiraea callosa, var. *rubra*.
Spiraea chamaedrifolia.
Spiraea lanceolata.
Spiraea salicifolia.
Spiraea prunifolia.
Neillia opulifolia. l.
Holodiscus discolor.
Cercocarpus betuloides, Mountain mahogany.

CALYCANTHEÆ.

Calycanthus occidentalis.

MYRTACEÆ.

Eucalyptus globulus, Blue gum.
Eucalyptus rostrata, Red gum.
Eucalyptus amygdalina, White peppermint tree.
Eucalyptus citriodora, Lemon gum.
Eucalyptus Eugenioides.
Eucalyptus Gunnii.
Eucalyptus obliqua, Stringy bark or Messmate tree.
Eucalyptus paniculata, White iron-bark.
Eucalyptus pilularis, Black butt.
Eucalyptus viminalis, Manna gum tree.
Eucalyptus resinifera, Red mahogany gum.
Eugenia myrtifolia.
Leptospermum laevigatum, New Zealand tea.
Metrosideros buxifolia.
Callistemon coccineum.
Callistemon lanceolatum, Bottle brush.
Melaleuca diosmifolia.
Melaleuca hypericifolia.
Melaleuca thymifolia.
Tristania conferta.
Myrtus communis, Myrtle.
Kunzea pomifera.
Psidium Cattleyanum, Strawberry guava.
Psidium pyriferum, Pear guava.
Punica granatum, Pomegranate.

LAGERSTRÖMIACEÆ.

Lagerströmia Indica, Crape myrtle.

ONAGRARIEÆ.

Fuchsia fulgens. hh.
Fuchsia minima.
Fuchsia longiflora.
Fuchsia corymbiflora. hh.
Fuchsia microphylla. hh.
Fuchsia globosa. hh.

CACTEÆ.

Opuntia Ficus-indica, Tuna, hedge cactus.
Opuntia nigrescens.
Opuntia angustata.
Phyllocactus crenatus.
Phyllocactus phyllanthus.
Cereus speciosissimus.
Cereus giganteus, Giant cactus.
Cereus flagelliformis.
Melocactus communis, Melon cactus.
Echinocactus Wislizeni.
Echinocactus Texensis.
Echinocactus pectinatus.

MESEMBRYANTHEMEÆ.

Mesembryanthemum acinaciforme.
Mesembryanthemum edule.
Mesembryanthemum gracile.
Mesembryanthemum spectabile.
Mesembryanthemum spinosum.
Mesembryanthemum tenuifolium.
Mesembryanthemum violaceum.
Mesembryanthemum emarginatum.
And several other species not identified.

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PASSIFLOREÆ.

Passiflora Coerulea.
Passiflora quadrangularis. g.
Tacsonia, three species. hh.

SAXIFRAGACEÆ.

Ribes grossularia, Gooseberry.
Ribes Menziesii, California prickly gooseberry. l.
Ribes rubrum, Common currant.
Ribes quercetorum, California yellow-flowered gooseberry.
Ribes sanguineum, California red-flowering currant. l.
Ribes nigrum. l.
Ribes divaricatum. l.
Ribes Californicum.
Philadelphus coronarius.
Carpenteria Californica.
Deutzia scabra.
Deutzia crenata.
Hydrangea hortensis, Hydrangea.

ESCALLONIACEÆ.

Escallonia glabra.
Escallonia Montevidensis.

HAMAMELIDEÆ.

Liquidamber styraciflua, Liquid amber, Sweet gum.

CARICACEÆ.

Carica Papaya, American pawpaw. g.
Vasconcella hastata. hh.

ARALIACEÆ.

Aralia spinosa.
Fatsia papyrifera, Rice-paper tree.
Hedera Helix, Ivy.
Hedera Hibernica, Irish ivy.

CAPRIFOLIACEÆ.

Viburnum tinus.
Viburnum lucidum.
Symphoricarpus racemosus. l.
Sambucus glauca, Elder. l.
Lonicera hispidula, Wild honeysuckle. l.
Lonicera Ledebourii. l.

CORNEÆ.

Cornus stolonifera. l.
Garrya elliptica.

RUBIACEÆ.

Galium Nuttallii. l.
Cephalanthus occidentalis, Button bush.
Pinckneya pubens, Georgia bark.
Bouvardia Davidsoni.
Bouvardia Vrelandi.
Coffea arabica, Coffee. g.
Cinchona officinalis, Cinchona bark. hh.
Cinchona succirubra, Red cinchona bark. g.
Cinchona Calisaya, Calisaya bark. g.
Cinchona hybrida, Hybrid bark. hh.
Cinchona Condaminea. hh.

COMPOSITÆ.

Eupatorium glechomophyllum.
Artemisia Californica, Shrubby wormwood. l.
Baccharis pilularis, Groundsel tree. l.
Grindelia cuneifolia.

ERICACEÆ.

Erica arborea, Tree heath.
Erica mediterranea, Mediterranean heath.
Arbutus Unedo, Strawberry tree.
Arbutus Menziesii, Madrona tree.
Azalea occidentalis, Western azalea.
Azalea Indica, Indian azalea, in variety. hh.
Gaultheria shallon, Bearberry.

PLUMBAGINEÆ.

Plumbago capensis, Leadwort.

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STYRACEÆ.

Styrax Californica, California storax.
Styrax Japonica, Japanese storax.
Halesia tetraptera, Snowdrop tree.

EBENACEÆ.

Diopyrus Virginiana, American persimmon.
Diopyrus digyna.
Diopyrus lotus, European persimmon.
Diopyrus Kaki, Japanese persimmon.

MYRSINEÆ.

Corynocarpus laevigatus, Karaka of New Zealand.

SAPOTACEÆ.

Achras Sapota, Sapodilla plum. g.
Bumelia tenax.
Argania Sideroxylon, Argan tree. hh.

SCROPHULARIACEÆ.

Buddleya globosa.
Paulownia imperialis.
Veronica salicifolia.
Veronica speciosa.
Veronica Andersoni.
Veronica paniculata.
Goldfussia anisophylla. g.
Libonia floribunda.
Diplacus glutinosus. l.
Diplacus parviflorus.
Russelia juncea. g.

BIGNONIACEÆ.

Catalpa speciosa, Hardy catalpa.
Catalpa cordifolia, Common catalpa.
Bignonia jasminoides.

VERBENACEÆ.

Callicarpa Americana, French mulberry.
Vitex agnus castus, Chaste tree.
Aloysia citriodora, Lemon verbena.

BORRAGINEÆ.

Heliotropium Peruvianum, Fragrant heliotrope. hh.

LABIATÆ.

Salvia coccinea.
Audibertia polystachya.
Audibertia nivea.
Prostanthera nivea.

CONVOLVULACEÆ.

Convolvulus luteolus.

SOLANACEÆ.

Habrothamnus elegans.
Iochroma tubulosum.
Fabiana imbricata.
Cestrum aurantiacum.
Lycium Andersoni, Buckthorn.

MYOPORINEÆ.

Myoporum insulare.

APOCYNACEÆ.

Nerium oleander.
Allamanda Schotti. g.
Allamanda cathartica. g.
Forsteronia difformis.

THYMELEACEÆ.

Dirca occidentalis.
Daphne collina?

ELEAGNEÆ.

Eleagnus Japonica.
Eleagnus pungens.

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OLEACEÆ.

Olea Europæa, Olive. (See fruit trees.)
Olea aquifolia, Holly-leaved olive.
Olea fragrans, Sweet-scented olive.
Ligustrum Japonicum, Japanese privet.
Ligustrum Italicum, Italian privet.
Ligustrum commune, Common privet.
Forsythia viridissima.
Syringa Japonica, Japanese lilac.
Syringa vulgaris, Common lilac.
Fraxinus Americana, American white ash.
Chionanthus Virginiana, Fringe tree.

LAURINEÆ.

Camphora officinarum, Japan camphor tree.
Lindera Benzoin, Spice bush.
Persea gratissima, Aguacate, alligator pear.
Persea Lingue, Lingue.
Cinnamonum glaucum, Cinnamon.
Cinnamonum sericeum.
Umbellularia Californica, California laurel, bay. l.
Bellota Mierrii.

PROTEACEÆ.

Hakea acicularis.
Banksia integrifolia.
Grevillea robusta, Australian fern tree.
Grevillea coccinea.
Macadamia ternata, N. Queensland nut tree.

PHYTOLACCACEÆ.

Dœringia angustata.

POLYGONACEÆ.

Eriogonum arborescens.
Mühlenbeckea platyclada.

URTICACEÆ.

Celtis occidentalis, Nettle tree.
Planera cuspidata, Japanese planer tree.
Ulmus compestris, Common English elm, var. *pendula.*
Ulmus suberosa, Cork elm.
Ficus carica, Fig. (See fruit trees.)
Morus alba, White mulberry.
Morus multicaulis.
Morus Moretti.
Morus nigra, Black mulberry.
Morus Japonica, Japanese mulberry.
Morus Downingii, Hybrid.
Platanus orientalis, Oriental sycamore.
Platanus occidentalis, American sycamore.
Maclura auantiaca, Osage orange.

EUPHORBIACEÆ.

Euphorbia splendens.
Stillingia Sebifera, Tallow tree.
Buxus communis, Common boxwood.
Poinsettia pulchenima.

JUGLANDEÆ.

Hicoria tomentosa, Mockernut.
Hicoria alba, Shellbark or shagbark hickory.
Hicoria Pecan, Pecan nut.
Hicoria glabra, Pignut hickory.
Juglans Sieboldtii, Japanese walnut.
Juglans regia, Madeira nut, or English walnut.
Juglans Californica, California walnut.

CUPULIFERÆ.

Fagus sylvatica, European beech.
Quercus Suber, Cork oak.
Quercus Robur, var. *pedunculata*, N. European oak, English oak.
Quercus Douglassii, Blue or California rock oak.
Quercus Kelloggii, California black oak.

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Quercus nigra, Black jack oak.
Quercus alba, (Eastern) White oak.
Quercus phellos, Willow oak.
Quercus imbricaria, Shingle oak.
Quercus coccinea, Scarlet oak.
Quercus tinctoria, Black oak.
Quercus falcata, Spanish oak.
Quercus Prinos, Swamp chestnut oak.
Quercus cinerea, Upland willow oak.
Quercus Catesbæi, Bowers' scrub oak.
Quercus agrifolia, California live oak. l.
Quercus lobata, California white oak.
Quercus densiflora, California chestnut oak.
Corylus Avellana, Hazelnut.
Corylus purpurea.
Corylus rostrata, Beaked hazel. l.
Castanea vesca, Italian chestnut.
Castanea Japonica, Japanese chestnut.
Castanea pumila, Chinquapin.

MYRICACEÆ.

Myrica cerifera, Bayberry.
Myrica Californica, California wax myrtle.

BETULACEÆ.

Betula alba, White birch.
Betula rubra, Red birch.
Alnus rubra.
Alnus rhombifolia.

SALICINEÆ.

Salix viminalis, Osier willow; Belgian, golden, and *nobilis.*
Salix amygdalina, var. *latifolia* and *Caucasian.*
Salix hippophaëfolia, Silver willow.
Salix cordata.
Salix purpurea.
Salix lasiolepis, Wild willow. l.
Salix laevigata, Wild willow. l.

CONIFERS.

Pinus parviflora, Small flowering pine.
Pinus Massoniana.
Pinus excelsa, Bhotan pine of Himalaya.
Pinus Canariensis, Canary Island pine.
Pinus Pinea, Italian nut pine.
Pinus maritima, European seacoast pine.
Pinus sylvestris, Scotch pine.
Pinus Austriaca, Austrian pine.
Pinus australis, Long-leaved pine.
Pinus Strobus, White pine.
Pinus radiata, Monterey pine.
Pinus contorta, Coast scrub pine.
Pinus muricata, Bishop's pine.
Pinus ponderosa, Yellow pine.
Pinus Sabiniana, Digger pine.
Pinus Coulteri, Great-coned pine.
Pinus Parryana.
Pinus tuberculata, California scrub pine.
Pinus Torreyana.
Pinus Llaveana, Nut pine.
Pinus monophylla, Nut pine.
Pinus Russelliana, Long-leaved Mexican pine.
Picea Menziesii, Menzies' spruce.
Picea grandis, Western balsam fir.
Picea amabilis, Silver fir.
Picea Cephalonica, Cephalonian silver fir.
Picea Pinsapo, Spanish fir.
Abies Douglassii, Douglass' spruce.
Abies Nordmanniana, Nordmann's silver fir.
Abies firma, Japanese fir.
Thuja gigantea, Port Orford cedar.
Thuja orientalis, Chinese arbor vitæ.
Thujopsis borealis, Nootka Sound cypress.
Thujopsis dolabeata.
Cryptomeria elegans.
Cryptomeria Japonica, Japan cedar.

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Libocedrus decurrens, California white cedar.
Cupressus Lawsoniana, Oregon white cedar.
Cupressus macrocarpa, Monterey cypress.
Cupressus elegans.
Cupressus Lusitanica, Portuguese cypress.
Cupressus Sinensis, Chinese cypress.
Cupressus pyramidalis.
Cupressus Africana.
Cupressus McNabiana, McNab's cypress.
Cupressus torulosa, Himalayan cypress.
Cupressus funebris, Funeral cypress.
Cupressus excelsa.
Cupressus Arizonica, Arizonian cypress.
Sequoia gigantea, California big tree.
Sequoia sempervirens, Redwood.
Juniperus Bermudiana, Bermuda juniper.
Juniperus Japonica, Japanese juniper.
Juniperus Japonica prostrata, Creeping Japanese juniper.
Juniperus Hibernica, Irish juniper.
Juniperus Virginiana, Red cedar.
Juniperus Sabina, Savin.
Juniperus Attica.
Dammara australis, Dammar pitch pine.
Callitris cupressiformis, Australian cypress.
Callitris verrucosa.
Gingko biloba, Gingko.
Taxodium distichum, Southern cypress.
Araucaria imbricata, Chili pine.
Araucaria excelsa, Norfolk Island pine.
Araucaria Bidwellii.
Cedrus deodara, Deodaro cedar.
Cedrus Libani, Cedar of Lebanon.
Podocarpus macrophylla.
Larix Europæa, European larch.
Taxus adpressa.
Taxus baccata, Common yew.
Torreya Californica, California nutmeg.

CYCADEÆ.

Cycas revoluta, False sago palm.

CASUARINEÆ.

Casuarina disticha, Horsetail pine.
Casuarina torulosa.
Casuarina stricta.

MONOCOTYLEDONS.

PALMEÆ.

Washingtonia filifera, California fan palm.
Washingtonia robusta, Arizonian palm.
Erythea edulis.
Erythea glauca.
Pritchardia Martii. hh.
Pritchardia Gaudichaudi. hh.
Phœnix dactylifera, Date palm.
Phœnix Canariensis.
Phœnix Leonensis.
Phœnix rupicula. hh.
Areca rubra. hh.
Latania Borbonica, Chinese fan palm. hh.
Corypha Australis.
Chamærops humilis, Dwarf European palm.
Chamærops excelsa.
Chamærops hystrix, Blue palmetto.
Jubæa spectabilis, Coquito of Chili.
Sabal Palmetto, Palmetto.
Thrinax argentea. hh.
Seaforthia elegans. hh.

LILIACEÆ.

Cordyline Forsteri, Palm lily.
Cordyline Australis.
Dracæna cannæfolia.
Dracæna terminalis.
Yucca Whipplei.

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Yucca aloëfolia.
Yucca filamentosa, Spanish bayonet.
Yucca recurva.
Yucca baccata.
Dasylirion Wheeleri.
Dasylirion serratifolium.
Xanthorrhœa Australis, Grass smilax tree of Australia.

MUSACEÆ.

Musa Ensete, Abyssinian banana. hh.
Musa Cavendishii, Dwarf or Chinese banana. hh.

PANDANEÆ.

Pandanus utilis. Screw palm. g.
Pandanus Veitchii. g.

GRAMINEÆ.

Thamnocalamus spathiflorus.
Arundinaria falcata.
Bambusa stricta.
Bambusa, four undetermined species.

APPENDIX No. 3.

LIST OF FRUIT TREES IN THE STATION ORCHARDS.

A. *List of Fruit Trees in the Orchards of the Experimental Grounds at Berkeley.*

PEACHES.

1. Early Alfred.
2. Victoria.
3. Albert.
4. Leopold.
5. Rivers' Early York.
6. Early Silver.
7. Troth's Early.
8. Early York.
9. McKevitt's Cling.
10. Cooledge's Favorite.
11. Haines' Early.
12. Bergen's Yellow.
13. Early Rivers.
14. Alberg's Yellow.
15. Sellers' Free.
16. Hale's Early.
17. Chinese Flat.
18. Early Rose.
19. Cole's Early Red.
20. Early Louise.
21. Early Beatrice.
22. Large Early York.
23. Large Early Mignonne.
24. Early Savoy.
25. Early Newington.
26. Richmond.
27. Canada, or Lake George Cling.
28. Dagmar.
29. Van Buren's Golden Dwarf.
30. Monstreuse of Douay.
31. Old Mixon Cling.
32. Muir.
33. Snow.
34. Atlanta.
35. Belle Coquette.
36. Jones' Seedling.
37. Surpasse Melocoton.
38. Royal Kensington.
39. Yellow Tuscany Cling.
40. Moore's Favorite.
41. Brevoort.
42. Hill's Madeira.
43. Crimson Galande.
44. Sellers' Cling.
45. Hicks' Seedling.
46. Comet.
47. White Tuscany Cling.
48. Foster.
49. Lemon Cling.
50. Raymacker's.
51. George the Fourth.
52. Strawberry.
53. Thissell Free.
54. Mammoth Melocoton.
55. Old Mixon Free.
56. Waterloo.
57. Late Morris White.
58. Stump-the-World.
59. Belle Dorée.
60. Delaney Heath Cling.
61. Dr. Hogg.
62. Belle Bausse.
63. Lady Palmerston.
64. Heath Free.
65. Tippecanoe Cling.
66. Pucelle de Malines.
67. Leopold the First.
68. Chevreuse Hâtive.

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69. White Melocoton.
70. Jacques' Rareripe.
71. Carmine.
72. Ward's Late Free.
73. Heath Cling.
74. Prince of Wales.
75. Magdala.
76. Scott's Nonpareil.
77. Vineuse.
78. Red Cheek Melocoton.
79. Walburton's Admirable.
80. Acton Scott.
81. Morris White.
82. Amsden.
83. Susquehanna.
84. Belle de la Croix.
85. The Nectarine.
86. De la Regandiere.
87. Royal George.
88. Grosse Mignonne.
89. Carpenter's White.
90. Alexander.
91. White Imperial.
92. Schumaker.
93. Ulatis.
94. Solway.

NECTARINES.

1. Early Violet.
2. Early Newington.
3. Rivers' Orange.
4. Boston.
5. Red Roman.
6. Hardwicke's Seedling.
7. Pitmaston's Orange.
8. Downton.
9. Victoria.
10. Late Melting.
11. Elruge.
12. Duc de Vitry.
13. New White.

APRICOTS.

1. Blenheim.
2. Breda.
3. St. Ambroise.
4. Red Masculine.
5. Turkey.
6. Hemskirke.
7. Early Moorpark.
8. Alberge de Montgamet.
9. Purple.
10. Malcom's Breda.
11. Sardinian.
12. Kaisha.
13. Newcastle.
14. Canino Grosso.
15. Peach.
16. Moorpark.
17. Shipley.
18. Large Early.
19. De Coulorge.
20. Routier Peach.
21. Luizet.
22. Bon Bon.
23. Beauge.
24. Orange.
25. Large Red.

PLUMS.

1. Ontario.
2. Bryanston's Gage.
3. Duane's Purple.
4. Bradshaw.
5. Blue Damson.
6. Red Magnum Bonum.
7. Imperial Gage.
8. Jefferson.
9. Green Gage.
10. Myrobalan.
11. General Hand.
12. Lucombe's Nonesuch.
13. Victoria.
14. Ronald's Fancy.
15. Lawrence's Favorite.
16. Quackenbos.
17. Monroe Gage.
18. Columbia.
19. Lombard.
20. Yellow Gage.
21. Reine Claude de Bavay.
22. Prince's Yellow Gage.
23. Smith's Orleans.
24. St. Lawrence.
25. Shropshire Damson.
26. McLaughlin.
27. Goliath.
28. Copper.
29. Judson.
30. Winesour.
31. Peter's Yellow Gage.
32. Pond's Seedling.
33. Prince of Wales.
34. Orange.
35. Bleeker's Gage.
36. Belgian Purple.
37. Drap d'Or d'Esperen.
38. Transparent Green Gage.
39. Coe's Golden Drop.
40. Washington.
41. Ives' Autumn.
42. Royal de Tours.
43. Autumn Compôte.
44. Peach.
45. Yellow Magnum Bonum.
46. Guthrie's Late Green.
47. Autumn Gage.
48. Diaprée Rouge.
49. Reine Claude Rouge.
50. Dennison's Superb.
51. New Large Bullace.
52. Morocco.
53. Cherry.

PRUNES.

1. Robe de Sergent.
2. Bulgarian.
3. Grosse Prune d'Agen.
4. Fellenberg.
5. Wangenheim.
6. German.
7. Prince Englebert.
8. St. Martin's.
9. Silver.
10. Simoni.

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11. Prune d'Agen.
12. Golden.
13. Shaw's.
14. Tragedy.
15. Glaister.

JAPAN PLUMS.

1. Blackman's.
2. Japan No. 3.
3. Botankio.
4. Long-fruited.
5. Masu.
6. Kelsey's.
7. Satsuma.
8. Burbank.

ALMONDS.

1. Languedoc.
2. Bidwell's Mammoth.
3. Wolfskill.
4. Commercial.
5. Ne Plus Ultra.
6. Rice's Twin.
7. Golden State.

CHERRIES.

1. Oregon.
2. Yellow Spanish.
3. Rockport.
4. Reine Hortense.
5. Kentish.
6. Napoleon.
7. Late Duke.
8. Great Bigarreau.
9. Late Mottled Bigarreau.
10. Brant.
11. Buttner's Yellow.
12. Bigarreau Riverchon.
13. Mervelle de Septembre.
14. Frogmore Bigarreau.
15. Early Lamaurie.
16. Black Tartarian.
17. Elton.
18. Gov. Wood.
19. Gridley.
20. Bell Crown.
21. Black Mastodon.
22. Centennial.
23. Monstreuse de Mezel.
24. Knight's Early Black.
25. American Amber.
26. Purity.
27. California Advance.
28. Downer's Late Red.
29. Manning's Mottled.
30. Montmorency a Longue Queue.
31. May Duke.
32. American Heart.
33. Plumstone Morello.
34. Jeffery's Duke.
35. Bigarreau Noir Hâtive.
36. Black Hawk.

PEARS.

1. Keiffer.
2. Le Conte.
3. P. Barry.
4. Bloodgood.
5. Edmonds.
6. Clapp's Favorite.
7. Doyenne d'Eté.
8. Col. Wilder.
9. Brandywine.
10. Tyson.
11. Bartlett.
12. Rostiezer.
13. Belle Lucrative.
14. Osband's Summer.
15. Dearborn's Seedling.
16. Beurré Giffard.
17. Madeline.
18. Beurré de Waterloo.
19. Gray Doyenne.
20. Doyenne Boussock.
21. Beurré Superfin.
22. Buffum.
23. Paul Ambre.
24. Louise Bonne de Jersey.
25. Beurré Diel.
26. Swan's Orange.
27. Beurré Bosc.
28. Idaho.
29. Napoleon.
30. Howell.
31. Sheldon.
32. Beurré Hardy.
33. Paradise de Autumne.
34. Urbaniste.
35. Conseiller de la Cour.
36. Doyenne White.
37. Oswego Beurré.
38. Beurré Langeier.
39. Doyenne du Comice.
40. Dana's Hovey.
41. Emile de Heyst.
42. Souvenir d'Esperen.
43. Dix.
44. Fulton.
45. Canandaigua.
46. Jones' Seedling.
47. Kirtland.
48. Stevens' Genessee.
49. Pratt.
50. Ott.
51. Kingsessing.
52. Beurré Amande.
53. Baronne de Mello.
54. Amire Joannet.
55. Flemish Beauty.
56. Duchesse d'Orleans.
57. Liberale.
58. Gratiola of Jersey.
59. Duchesse de Berry d'Eté.
60. Doyenne Robin.
61. Beurré Golden of Bilbao.
62. Bonne d'Ezée.
63. Beurré Goubalt.
64. Vicar of Winkfield.
65. Nouveau Poiteau.
66. Nantais.
67. Henry the Fourth.
68. De Tongres.
69. Jalousie de Fontenay Vendée.
70. Rousselet Stuttgart.

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71. St. Michael Archange.
72. Ananas d'Eté.
73. Andrews.
74. Beurré d'Anjou.
75. Seckel.
76. Duchesse d'Angoulême.
77. Beurré Sterkmans.
78. Beurré Clairgeau.
79. Maurice Desportes.
80. Williams' D'Hiver.
81. Madame Lorial de Barney.
82. Bonne du Puits Ausault.
83. Sarah.
84. Madame Treyve.
85. Pitmaston's Duchesse d'Angoulême.
86. Duhamel de Monceau.
87. Souvenir du Congres.
88. Duchesse of Bordeaux.
89. Duchesse Précoce.
90. Marechal Vaillant.
91. Petite Marguerite.
92. St. Crispin.
93. Brockworth Park.
94. Eugène Appert.
95. Louis Vilmorin.
96. Beurré de la Assomption.
97. Napoleon the Third.
98. Levard.
99. Mount Vernon.
100. Madame Cuissard.
101. Anne Ogereau.
102. Court Queen d'Autumne.
103. André Desportes.
104. Duchesse de Mouchy.
105. Dr. Reeder.
106. Rutter.
107. Jaminette.
108. Columbia.
109. Bergamotte d'Esperen.
110. Doyenne d'Alençon.
111. Lawrence.
112. Buerré Gris d'Hiver Nouveau.
113. Augustus Dana.
114. Josephine de Malines.
115. America.
116. Manning's Elizabeth.
117. Chaumontel.
118. Prince St. Germaine.
119. Star of Bethlehem.
120. Washington.
121. Figue d'Alençon.
122. Moyamensing.
123. Bonne Sophie.
124. Chaptal.
125. Doyenne Sieulle.
126. Calabasse Monstreuse.
127. Beurré Précoce.
128. Beauprésent d'Artois.
129. Beurré d'Aremberg.
130. St. Germain.
131. Bergamotte Cadet.
132. Belle Williams.
133. Epine Dumas.
134. Fondante de Noöl.
135. Inconnue Von Mons.
136. Marie Louise d'Uccles.
137. St. André.
138. Pater Noster.
139. Passe Colmar.
140. Bezi Sanspareil.
141. Winter Nelis.
142. Glout Morçeau.
143. Pound.
144. Beurré Easter.
145. Forelle.
146. Lankford.
147. Theresa Apperent.

APPLES.

1. Calville Rouge d'Eté.
2. Sops of Wine.
3. Tetofsky.
4. Kirkbridge White.
5. Seedless.
6. Serinka.
7. Garretson's Early.
8. Sweet June.
9. Summer Hagloe.
10. Keswick Codlin.
11. Summer Queen.
12. Hominy.
13. Julien.
14. McCloud's Family.
15. Summer Rose.
16. Summer Bellflower.
17. Primate.
18. Benoni.
19. Red Astrachan.
20. Skinner's Seedling.
21. Golden Sweet.
22. Early Harvest.
23. Early Joe.
24. Disharoon.
25. Fall Wine.
26. Pomme Royale.
27. Jersey Sweet.
28. Pumpkin Sweet.
29. Mangum.
30. Hawthornden.
31. Hall.
32. Fall Jenneting.
33. Alexander.
34. Sherwood's Favorite.
35. Yopp's Favorite.
36. Buckingham.
37. Munson Sweet.
38. Red Fall Pippin.
39. Carolina Red June.
40. Dahlonega.
41. St. Lawrence.
42. Porter.
43. Lowell.
44. Autumn Strawberry.
45. Smokehouse.
46. Rhode Island Greening.
47. Duchess of Oldenburgh.
48. Autumn Bough.
49. Cogswell.
50. Jeffries.
51. Gravenstein.
52. King of Tompkins County.
53. Twenty-ounce.
54. Canada Reinette.
55. Rambo.
56. Maiden's Blush.
57. Clyman's Seedling.
58. Gloria Mundi.
59. Golden Russet.
60. Talman's Sweet.
61. Peck's Pleasant.
62. Roxbury Russet.
63. Lady.
64. Grimes' Golden Pippin.
65. Flower of Kent.
66. Fallawater.
67. Wall.
68. Hubbardston's Nonesuch.

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69. Northern Spy.
70. Shockley.
71. Nickajack.
72. Red Warrior.
73. Seek-No-Further.
74. Maverick Sweet.
75. Berry.
76. Cullasaga.
77. Mother.
78. Pomme Grise.
79. Fameuse.
80. Domine.
81. Ben Davis, or New York Pippin.
82. Willow Twig.
83. Red Canada.
84. Lyman's Pumpkin Sweet.
85. Blackshear.
86. Equinetely.
87. Carter.
88. White Pippin.
89. Duckett.
90. Cooper's Market.
91. Belmont.
92. Prior's Red.
93. Reinette Canada.
94. Bailey's Sweet.
95. Fanny.
96. Green Sweeting.
97. Swaar.
98. McLellan.
99. Vandevere.
100. English Russet.
101. Wells' Sweet.
102. Dutch Mignonne.
103. McAffee's Nonesuch.
104. Chestatee.
105. Hall.
106. Ortley.
107. Jonathan.
108. Smith's Cider.
109. Rawle's Janet.
110. Baldwin.
111. Yellow Bellflower.
112. Wagener.
113. White Winter Pearmain.
114. Esopus Spitzenberg.
115. Rome Beauty.
116. Hoover.
117. Grand Duke Constantine.
118. Cardinal.
119. Pigeon.
120. Count Orloff.
121. Grand Sultan.
122. Dickinson.
123. Edwards' Sweet.
124. Mammoth Black Sweet.
125. Huntsman.
126. Morton's Pearmain.
127. Clayton.
128. Ingram.
129. Arkansas Black.
130. Shackleford.
131. Borsdoffer.
132. Challotten Thaler.
133. Clyman's Pippin.
134. Violet.
135. Clyde Beauty.
136. Junaluskee.

Crab-apples.

1. Oblong.
2. Montreal.
3. Chicago.
4. Coral.
5. Red Siberian.
6. Currant.
7. Transcendent.
8. Large Yellow.
9. Ringo.
10. Malus Carda.
11. Hews' Virginia.
12. Lady.
13. Yellow Siberian.
14. Hyslop.
15. Large Red.

Quinces.

1. Mammoth.
2. Champion.
3. Apple.
4. Japan.

Figs.

1. Rargigna.
2. Zimeia.
3. Cernica.
4. Breba.
5. Smyrna.
6. White Adriatic.

Japan Persimmons.*

1. Hachiya.
2. Tassmoke.
3. Gubaska.
4. Tanamegaru.
5. Yuma.
6. Dai Dai Maru.

* All these persimmons are questionable as to name.

Carob Trees.

Ceratonia Siliqua, seedlings from seed from Redington & Co., San Francisco.

Mulberries.

1. Downing's Everbearing.
2. Multicaulis.
3. Nagasaki.
4. Alba.
5. Lhoo.
6. Russian.

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OLIVES.

1. Atro-violacea Seedling.
2. Nigerrima Seedling.
3. Buxifolia Seedling.
4. Præcox Seedling.
5. Rubra Seedling.
6. Uvaria Seedling.
7. Atro-rubens Seedling.
8. Nevadillo blanco.
9. Rubra.
10. Polymorpha.
11. Nigerrima.
12. Oblonga.
13. Atro-violacea.
14. Regalis.
15. Columbella.
16. Atro-rubens.
17. Manzanillo.
18. Macrocarpa.
19. Conditiver.
20. Correggiolo.
21. Amellan.
22. Lucques.
23. Razzo.
24. Herveza.
25. Lavaningo.
26. Obliza.
27. Uvaria.
28. Early Mission.
29. Broad-leaved Mission.
30. Mission, 1, 2, 3.

B. List of Fruit Trees Planted at the Sub-stations.

NOTE.—An "r" opposite a name indicates that the variety is represented at the station named at the head of the column.

VARIETY.	Amador.	Paso Robles.	Tulare.
APPLES.			
Summer.			
Benoni	r	r	----------
Early Harvest	r	r	----------
Early Strawberry	r	r	----------
Gravenstein	r	r	r
Keswick Codlin	r	r	r
Maiden's Blush	r	r	----------
Red Astrachan	r	r	r
Red June	r	r	----------
White Astrachan	r	r	r
Autumn.			
Alexander	r	r	r
Beauty of Kent	r	r	----------
Fall Pippin	r	r	----------
Fameuse	r	r	r
Gloria Mundi	r	r	r
Hoover	r	r	r
Jonathan	r	r	r
King	r	r	----------
Mother	r	r	----------
Porter	r	r	----------
Rhode Island Greening	r	r	r
Roxbury Russet	r	r	----------
Skinner's Seedling	r	r	r
Twenty-ounce	r	r	r
Rambo	r	r	----------
Winter.			
Golden Russet American	r	r	----------
Bailey's Sweet	r	r	----------
Baldwin	r	r	----------
Ben Davis	r	r	----------
Buckingham	r	r	----------
English Golden Russet	r	r	----------
Esopus Spitzenberg	r	r	r
Grimes' Golden Pippin	r	r	r
Haas	r	r	----------
Lady Apple	r	r	r
Ladies' Sweeting	r	r	----------
Limber Twig	r	r	----------
Lawyer	r	r	r
Mann	r	r	----------
Missouri Pippin	r	r	r
Nickajack	r	r	----------
Northern Spy	r	r	r

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List of Fruit Trees—Continued.

Variety.	Amador.	Paso Robles.	Tulare.
Ortley	r	r	r
Peck's Pleasant	r	r	----------
Pewaukee	r	r	r
Prior's Red	r	r	----------
Rawle's Janet	r	r	----------
Red Canada	r	r	----------
Red Cheeked Pippin	r	r	----------
Ribston Pippin	r	r	----------
Rome Beauty	r	r	----------
Smith's Cider	r	r	r
Sonoma	r	r	r
Stark	r	r	----------
Stump	r	r	r
Swaar	r	r	----------
Talman's Sweeting	r	r	----------
Vandevere	r	r	----------
Wagener	r	r	----------
Walbridge	r	r	r
Wealthy	r	r	r
White Winter Pearmain	r	r	r
Wine Sap	r	r	----------
Wolf River	r	r	r
Yellow Bellflower	r	r	r
Yellow Newtown Pippin	r	r	r
Unclassified.			
Amassia	r	r	----------
Colvert	r	r	----------
Duke of Devonshire	r	r	----------
Early Ripe	r	r	----------
Flora Bell	r	r	----------
McMahon's White	r	r	r
Perry Russet	r	r	----------
Red Bietigheimer	r	r	r
Reinette de Caux	r	r	----------
Sweet June	r	r	----------
Trenton Early	r	r	----------
York Imperial	r	r	----------
Marshall's Seedling	r	r	r
Arkansas Black	r	r	r
Red Delaware	r	r	r
Mammoth Black Twig	r	r	r
Bledsoe	r	r	r
Shannon	r	r	r
Red Winter Pearmain	r	r	r
Shirley	r	r	r
Loy	r	r	r
Steward	r	r	r
Lincoln	r	r	r
Gano	r	r	----------
Forest	r	r	----------
Violet	r	r	r
Excelsior	r	r	r
Acme	r	r	r
Clyman's	r	r	r
CRAB-APPLES.			
Hyslop	r	r	r
Montreal Beauty	r	r	r
Transcendent	r	r	----------
Whitney	r	r	r
Yellow Siberian	r	r	r
PEARS.			
Summer.			
André Desportes	r	r	r
Bartlett	r	r	r
Beurré d'Amanlis	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
Beurré Giffard	r	r	r
Bloodgood	r	r	r
Clapp's Favorite	r	r	r
Dearborn's Seedling	r	r	r
Doyenne d'Été	r	r	r
Le Conte	r	r	r
Madeleine	r	r	r
Souvenir du Congres	r	r	r
Tyson	r	r	r
Autumn.			
Belle Lucrative	r	r	r
Black Pear of Worcester	r	r	r
Beurré Bosc	r	r	r
Beurré Clairgeau	r	r	r
Beurré d'Anjou	r	r	r
Beurré Diel	r	r	r
Beurré Hardy	r	r	r
Beurré Superfin	r	r	r
B. S. Fox	r	r	r
Brockworth Park	r	r	r
Columbia	r	r	r
Dana's Hovey	r	r	r
Dix	r	r	r
Doyenne Boussock	r	r	r
Doyenne du Comice	r	r	r
Duchesse d'Angoulême	r	r	r
Flemish Beauty	r	r	r
Frederick Clapp	r	r	r
Gray Doyenne	r	r	r
Gansel's Bergamotte	r	r	r
Howell	r	r	r
Keifer's Hybrid	r	r	r
Lawrence	r	r	r
Louise Bonne de Jersey	r	r	r
Mount Vernon	r	r	r
Onondaga	r	r	r
Paradis d'Automne	r	r	r
Seckel	r	r	r
Sheldon	r	r	r
Van Mons Leon le Clerc	r	r	r
White Doyenne	r	r	r
Urbaniste	r	r	r
Winter.			
Beurré Gris d'Hiver	r	r	r
Col. Wilder	r	r	r
Doyenne d'Alençon	r	r	r
Easter Beurré	r	r	r
Emile d'Heyst	r	r	r
Forelle	r	r	r
Glout Morceau	r	r	r
Jean de Witte	r	r	r
Josephine de Malines	r	r	r
Nouveau Poiteau	r	r	r
P. Barry	r	r	r
Pound	r	r	r
Vicar of Winkfield	r	r	r
Lawson or Comet	r	r	r
Dr. Reeder	r	r	r
Jaminette	r	r	r
Winter Nelis	r	r	r
Idaho	r	r	r
Kennedy	r	r	r
Conseiller del a Cour	r	r	r
Beurré Gris d'Hiver Nouveau	r	r	r
Cole	r	r	r

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List of Fruit Trees—Continued.

Variety.	Amador.	Paso Robles.	Tulare.
CHERRIES.			
Hearts and Bigarreaus.			
Baumann's May	r	r	----
Belle d'Orleans	r	r	----
Black Tartarian	r	r	r
Burr's Seedling	r	r	----
Cleveland Bigarreau	r	r	----
Coe's Transparent	r	r	----
Early Purple Guigne	r	r	----
Elton	r	r	----
Governor Wood	r	r	----
Great Bigarreau	r	r	r
Knight's Early Black	r	r	----
Lincoln	r	r	----
Lewelling	r	r	----
Pontiac	r	r	----
Rockport Bigarreau	r	r	r
Tradescant's Blackheart	r	r	----
Werder's Early Black	r	r	----
Willamette	r	r	----
Windsor	r	r	----
Yellow Spanish	r	r	----
Napoleon Bigarreau	r	r	r
Black Eagle	r	r	----
California Advance	r	r	r
Centennial	r	r	r
Purity	r	r	r
Black Mastodon	r	r	r
Early Rivers	r	r	----
Guigne Trés Précoce	r	r	----
Major Francis	r	r	----
Schmidt's Bigarreau	r	r	----
Duchesse de Palluau	r	r	----
Nouvelle Royale	r	r	----
Dukes and Morellos.			
Belle Magnifique	r	r	r
Early Richmond	r	r	r
Empress Eugenie	r	r	r
English Morello	r	r	r
May Duke	r	r	r
Olivet	r	r	r
Reine Hortense	r	r	r
Olivet, on Mahaleb stock	r	r	----
May Duke, on Mahaleb stock	r	r	----
Nouvelle Royale, on Mahaleb stock	r	r	----
PLUMS.			
Bavay's Green Gage	r	r	r
Bradshaw	r	r	r
Cherry	r	r	r
Coe's Golden Drop	r	r	r
Coe's Late Red	r	r	r
Columbia	r	r	r
Duane's Purple	r	r	r
Damson	r	r	r
Early Golden Drop	r	r	r
General Hand	r	r	r
Royal Hâtive	r	r	r
Smith's Orleans	r	r	r
Imperial Gage	r	r	r
Belle de Septembre	r	r	r
Green Gage	r	r	r
Czar	r	r	r
Ickworth Imperatrice	r	r	r
Damas Noir	r	r	r
Oullin's Golden	r	r	r
Perdrignon Blanc	r	r	r
Precoçe de Berthold	r	r	r
Rivers' Early Prolific	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
Japanese.			
Botan	r	r	r
Chabot Blood	r	r	r
Kelsey Japan, on Myrobalan	r	r	r
Prunus Simoni	r	r	r
Burbank	r	r	r
Satsuma			
Japan No. 3	r	r	r
Botankio	r	r	r
Long-fruited Japan	r	r	r
Masu	r	r	r
On Peach Stocks.			
Columbia	r	r	r
Damson	r	r	r
Victoria	r	r	r
Duane's Purple	r	r	r
Imperial Gage	r	r	r
Peach	r	r	r
Jefferson	r	r	r
Prince Englebert	r	r	r
Yellow Egg	r	r	r
Coe's Golden Drop	r	r	r
Glaister	r	r	r
Clyman	r	r	r
Chickasaw.			
Blackman	r	r	r
Marianna	r	r	r
On Myrobalan Stock.			
Goliath	r	r	r
Copper Plum	r	r	r
Judson	r	r	r
Winesour	r	r	r
Peter's Yellow Gage	r	r	r
Prince of Wales	r	r	r
Orange	r	r	r
Belgian Purple	r	r	r
Drap D'or d'Esperen	r	r	r
Transparent Green Gage	r	r	r
Ives' Autumn	r	r	r
Royale de Tours	r	r	r
Autumn Compôte	r	r	r
Peach	r	r	r
Yellow Magnum Bonum	r	r	r
Guthrie's Late Green	r	r	r
Autumn Gage	r	r	r
Diaprée Rouge	r	r	r
Reine Claude Rouge	r	r	r
Dennison's Superb	r	r	r
Bulgarian Prune	r	r	r
Kelsey Japan, on Peach	r	r	r
Satsuma	r	r	r
Petite d'Agen	r	r	r
Ontario	r	r	r
Duane's Purple	r	r	r
Red Magnum Bonum	r	r	r
Jefferson	r	r	r
Pond's Seedling	r	r	r
Lucomb's Nonesuch	r	r	r
Victoria	r	r	r
Ronald's Fancy	r	r	r
Lawrence Favorite	r	r	r
Quackenbos	r	r	r
Monroe Gage	r	r	r
Columbia	r	r	r
Lombard	r	r	r
Yellow Gage	r	r	r
Prince's Yellow Gage	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
St. Lawrence	r	r	r
Shropshire Damson	r	r	r
McLaughlin	r	r	r
On both Peach and Myrobalan Stock.			
Prince Englebert	r	r	r
St. Martin's Prune	r	r	r
Silver Prune	r	r	r
Coe's Golden Drop	r	r	r
Bryanston's Gage	r	r	r
Bradshaw	r	r	r
Blue Damson	r	r	r
Imperial Gage	r	r	r
Green Gage	r	r	r
Fellenberg	r	r	r
General Hand	r	r	r
Wangenheim	r	r	r
German Prune	r	r	r
Blackman's	r	r	r
PRUNES.			
Barry	r	r	r
Brignole	r	r	r
Datte de Hongrie	r	r	r
Fellenberg	r	r	r
German	r	r	r
St. Catherine	r	r	r
St. Martin's Quetsche	r	r	r
Wangenheim	r	r	r
Bulgarian	r	r	r
Petite d'Agen, on Peach	r	r	r
Petite d'Agen, on Almond	r	r	r
Robe de Sargent, on Apricot and on Myrobalan	r	r	r
Silver Prune, on Apricot and on Myrobalan	r	r	r
Golden Prune	r	r	r
Bassford's Prune	r	r	r
PEACHES.			
a. Freestone on Peach Stock.			
Amsden's June	r	r	r
Briggs' Red May	r	r	r
Governor Garland	r	r	r
Early Rivers	r	r	r
Yellow St. John	r	r	r
Mountain Rose	r	r	r
Coolidge's Favorite	r	r	r
Large Early York	r	r	r
Foster	r	r	r
Early Crawford	r	r	r
Noblesse	r	r	r
Wheatland	r	r	r
Columbia	r	r	r
Morris White	r	r	r
Late Admirable	r	r	r
Late Crawford	r	r	r
Newhall	r	r	r
Smock's Late Free	r	r	r
Beer's Smock	r	r	r
Ward's Late Free	r	r	r
Bonanza	r	r	r
Billieu's Late	r	r	r
Italian Dwarf	r	r	r
b. Clingstone on Peach Stock.			
Blood	r	r	r
Chinese	r	r	r
California	r	r	r
Crimson Beauty	r	r	r
George's Late	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
Heath	r	r	r
Large White Cling	r	r	r
Newington	r	r	r
Nichols' Orange	r	r	r
Runyon's Orange	r	r	r
Sellers'	r	r	r
Of Recent Introduction.			
Brandywine	r	r	r
Elberta	r	r	r
Henrietta Cling	r	r	r
Jennie Worthen	r	r	r
Lovell	r	r	r
La Grange	r	r	r
McDevitt's Cling	r	r	r
Mrs. Brett	r	r	r
Wager	r	r	r
Wilkins' Cling	r	r	r
On Myrobalan Stock.			
Early Alfred	r	r	r
Early Victoria	r	r	r
Early Leopold	r	r	r
Rivers' Early York	r	r	r
Early Silver	r	r	r
Troth	r	r	r
Early York	r	r	r
Haine's Early	r	r	r
Bergen's Yellow	r	r	r
Alberge Yellow	r	r	r
Sellers' Free	r	r	r
Cole's Early	r	r	r
Early Beatrice	r	r	r
Large Early York	r	r	r
Large Early Mignonne	r	r	r
Early Savoy	r	r	r
Early Newington	r	r	r
Richmond	r	r	r
President	r	r	r
Canada Cling	r	r	r
Van Buren's Golden Dwarf	r	r	r
Monstreuse of Douay	r	r	r
Snow	r	r	r
Atlanta	r	r	r
Jones' Seedling	r	r	r
Surpasse Melocoton	r	r	r
Hill's Madeira	r	r	r
Crimson Garland	r	r	r
Hicks' Seedling	r	r	r
Comet	r	r	r
White Tuscany Cling (Tozetti)	r	r	r
Raymacker	r	r	r
George the Fourth	r	r	r
Mammoth Melocoton	r	r	r
Late Morris White	r	r	r
Stump-the-World	r	r	r
Malta	r	r	r
Belle Douay	r	r	r
Delaney's Heath Cling	r	r	r
Dr. Hogg	r	r	r
Belle Bausse	r	r	r
Lady Palmerston	r	r	r
Heath's Free	r	r	r
Tippecanoe Cling	r	r	r
Pucelle de Malines	r	r	r
Leopold the First	r	r	r
Chevreuse Hâtive	r	r	r
White Melocoton	r	r	r
Jacques Rareripe	r	r	r
Carmine	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
Prince of Wales	r	r	r
Magdala	r	r	r
Scott's Nonpareil	r	r	r
Vineuse	r	r	r
Red Cheeked Melocoton	r	r	r
Walburton's Admirable	r	r	r
Acton Scott	r	r	r
Morris' White	r	r	r
Belle de la Croix	r	r	r
Nectarine	r	r	r
De la Régandière	r	r	r
Carpenter's White	r	r	r
Moore's Favorite	r	r	r
Freestone, on both Peach and Myrobalan Stock.			
Alexander	r	r	r
Waterloo	r	r	r
Hale's Early	r	r	r
Strawberry	r	r	r
Grosse Mignonne	r	r	r
Royal George	r	r	r
Old Mixon Free	r	r	r
Susquehanna	r	r	r
Stump-the-World	r	r	r
Salway	r	r	r
Clingstone, on both Peach and Myrobalan Stock.			
Lemon	r	r	r
Old Mixon	r	r	r
APRICOTS.			
On Apricot Stock.			
De Coulorge	r	r	r
Musch Musch	r	r	r
Oullin's Early	r	r	r
Pringle	r	r	r
Rivers' Early	r	r	r
Royal Russian	r	r	r
Viard	r	r	r
On Myrobalan Stock.			
Early Golden	r	r	r
Red Masculine	r	r	r
Turkey	r	r	r
Early Moorpark	r	r	r
Malcom's Breda	r	r	r
Canino Grosso	r	r	r
De Coulorge	r	r	r
Orange	r	r	r
Long Red	r	r	r
On both Apricot and Myrobalan Stock.			
Beauge	r	r	r
Blenheim	r	r	r
Breda	r	r	r
Hemskirk	r	r	r
Kaisha	r	r	r
Large Early Montgamet	r	r	r
Moorpark	r	r	r
Peach	r	r	r
Purple or Black	r	r	r
Sardinian	r	r	r
St. Ambroise	r	r	r
NECTARINES.			
Lord Napier	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
On Myrobalan Stock.			
Early Violet	r	r	r
Rivers' Orange	r	r	r
Red Roman	r	r	r
Pitmaston's Orange	r	r	r
Late Melting	r	r	r
Duc de Vitry	r	r	r
On both Peach and Myrobalan Stock.			
New White	r	r	r
Early Newington	r	r	r
Boston	r	r	r
Hardwick's Seedling	r	r	r
Downton	r	r	r
Victoria	r	r	r
Elruge	r	r	r
Stanwick	r	r	r
QUINCES.			
Apple or Orange	r	r	r
Angers	r	r	
Champion	r	r	
Portugal	r	r	
Rea's Mammoth	r	r	
Chinese	r	r	r
Meech's Prolific	r	r	
FIGS.			
Black Ischia	r	r	r
Brunswick	r	r	r
California Black	r	r	r
White Ischia	r	r	r
Adriatic	r	r	r
Smyrna	r	r	r
Dalmatian	r	r	r
San Pedro	r	r	r
Agen	r	r	r
Angeline	r	r	r
Black Bourjassotte	r	r	r
Col di Signora Nero	r	r	r
Early Violet	r	r	r
White Bourjassotte	r	r	r
New Varieties.			
Monaca Bianca	r	r	r
Pasteliere	r	r	r
White Marseilles	r	r	r
Hirtu du Japon	r	r	r
Du Roi	r	r	r
Brown Turkey	r	r	r
Grossale	r	r	r
Grosse Gris Bifere	r	r	r
Dorée Narbus	r	r	r
Ronde Noir	r	r	r
Black Marseilles	r	r	r
Drap d'Or	r	r	r
Royal Vineyard	r	r	r
White Genoa	r	r	r
Ronde Violette Hâtive	r	r	r
Abondance Précoce	r	r	r
Ladora	r	r	r
Rocardi	r	r	r
Negro Largo	r	r	r
Col di Signora Bianca	r	r	r
Barnisotte Gris	r	r	r
Raby Castle	r	r	r
Brown Ischia	r	r	r
De Constantine	r	r	r
Osborne Prolific	r	r	r
Bulletin Smyrna No. 1	r	r	r
Bulletin Smyrna No. 2	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
ALMONDS.			
Harriott's Seedling	r	r	r
King's Soft Shell	r	r	r
Languedoc	r	r	r
Marie Dupreys	r	r	r
Paper Shell	r	r	r
Pistache	r	r	r
Sultana	r	r	r
Drake's Seedling	r	r	r
IXL	r	r	r
Nonpareil	r	r	r
CHESTNUTS.			
American Sweet	r	r	r
Italian or Spanish	r	r	r
Marron de Lyon	r	r	r
Numbo	r	r	r
FILBERTS.			
English Red	r	r	----------
Purple Leaved	r	r	----------
Nottingham Prolific	r	r	----------
Dwarf Prolific	r	r	----------
Casford Nut	r	r	----------
Casford Thin-shelled	r	r	----------
Précoce de Frauendorf	r	r	----------
Géant de Halle	r	r	----------
Cut Leaved	r	r	----------
Imperial de Trebizonde	r	r	----------
Merveille de Bollwiller	r	r	----------
PECAN NUT.			
Pecan Nut	r	r	r
BUTTERNUTS.			
Butternut	r	r	r
WALNUTS.			
California Black	r	r	r
Bijou	r	----------	----------
Chaberte	r	r	r
Common English, or Madeira Nut	r	r	----------
Dwarf Prolific (on California stock)	r	r	r
Mayette	r	r	----------
Serotina, or St. John	r	r	----------
Franquette	r	r	r
American Black	r	r	r
Vourey	r	r	r
Persian	r	r	----------
ORANGES.			
Konah	r	r	r
Maltese Blood	r	r	r
Washington Navel	r	r	r
OLIVES.			
Atro-rubens	r	r	r
Atro-violacea	r	r	r
Columbella	r	r	r
Macrocarpa	r	r	r
Nigerrima	r	r	r
Oblonga	r	r	r
Pendulina	r	r	r
Polymorpha	r	r	r
Præcox	r	r	r
Regalis	r	r	r
Rubra	r	r	r
Rufa	r	r	r
Salonica	r	r	r
Uvaria	r	r	r

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LIST OF FRUIT TREES—Continued.

VARIETY.	Amador.	Paso Robles.	Tulare.
Nevadillo blanco	r	r	r
Manzanillo (No. 2, Bulletin 85)	r	r	r
Correggiolo	r	r	r
Razzo	r	r	r
Herveza	r	r	r
Obliza	r	r	r
Dalmatian	r	r	r
Lucques	r	r	r
Amellan	r	r	r
Lavanigno	r	r	r
POMEGRANATE.			
Sweet fruited	r	r	r
CURRANTS.			
Black Naples	r	r	
Fay's Prolific	r	r	
Cherry	r	r	
White Grape	r	r	
GOOSEBERRIES.			
Berkeley	r	r	
Downing	r	r	
Champion	r	r	
BLACKBERRIES.			
Crandall's Early	r		
Lawton	r		
Wilson's Early	r		
MULBERRIES.			
Lhoo	r		r
Nagasaki		r	r
White Mulberry	r	r	r
Italian	r	r	r
Russian	r	r	r
PLUM SEEDLINGS.			
Myrobalan	r	r	r
EXOTIC.			
Hovenia Dulcis		r	

APPENDIX No. 4.

LIST OF THE DIFFERENT VARIETIES OF CULTIVATED GRAPEVINES AND TYPES OF WILD VINES (OF THE GENUS VITIS) REPRESENTED AT THE SEVEN DIFFERENT STATIONS.

BORDEAUX TYPE.

Cabernet Sauvignon.
Cabernet Franc.
St. Macaire.
Gros Verdot.
Petit Verdot.
Merlot.
Beclan.
Tannat.
Gamay Teinturier.
Gros Mancin.
Charbono.
Teinturier mâle.
Pied de Perdrix.
Malbeck.

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Burgundy Type.

Pinot de Pernand.
Pinot de St. Georges.
Blauer Burgunder.
Meunier.
Chauché noir.
Robin noir (Pfeffer's Cabernet).

White Pinots.

Pinot Chardonay.
Pinot vert doré (?).

Southern French Type—*Red.*

Petite Sirah.
Mondeuse.
Bastardo.
Trousseau.
Cinsaut.
Matarò.
Ploussard.
Carignane.
Grenache.
Petit Bouschet.
Alicante Bouschet.
Tinta Val-de-peñas.
Aramon.
Mourastel.
Etraire de l'Adhui.

Southern French Type—*White.*

Roussanne.
Marsanne.
Clairette blanche.
Chauché gris.
Verdal.
Chasselas de Fontainebleau.
Early Silver Frontignan.
Ugni blanc.
Chasselas rose.

Sauterne Type.

Semillon blanc.
Sauvignon blanc.
Sauvignon vert.
Muscadelle du Bordelais.
Folle Blanche.
Burger.

Rhenish Type—*Red.*

Ruländer.
Affenthaler.

Rhenish Type—*White.*

Kleinberger.
Johannisberg Riesling.
Franken Riesling (Sylvaner).
Gewürz Traminer.
Zierfahndler (?).
Muscateller (Muscat blanc).

Hungarian, Austrian, and Tyrolean Type.

Peverella.
White Tokay.
Zinfandel.
Slankamenka.
Green Hungarian.
Lagrain.
Grüner Valtelliner.
Welsh Riesling.
Rothgipfler.
Bakator (rouge).
Kadarka.
Marzemino.
Blue Portuguese.
Gross blaue.

North Italian Type.

Nebbiolo fino.
Nebbiolo Bourgu.
Freisa de Montferrate.
Barbera fina.
Bonarda.
Barba corba gelata.
Provinante.
Aleatico.
Refosco.
Crabb's Burgundy (Refosco?).

Port Type.

Tinta de Madeira.
Tinta Amarella.
Tinta Cao.
Moretto.
Mourisco preto.
California Black Malvoisie.
Mission.
Black Prince.

Sherry and Madeira Type.

Boal de Madeira.
Feher Szagos.
Palomino.
Pedro Jimenes.
Verdelho.
West's White Prolific.
Beba.
Malmsey.
Peruno.
Mantuo de Pilas.
Mourisco branco.

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TABLE AND RAISIN—*White.*

Muscat of Alexandria.
Huasco.
Canon Hall Muscat.
Bowood Muscat.
Almeria.
Pizzutello di Roma.
Steinschiller.
Gelbe Seidentraube (Lignanga).
White Vernaccia.
Golden Queen.
Sultana (round-berried).
Thomson's Seedless (oblong-berried Sultana).
White Corinth.
Syrian.
White Nice.
White Malaga.

TABLE—*Red and Black.*

Purple Cornichon.
Sabalkansky.
Black Ferrara.
Emperor.
Black Muscat.
Gros Maroc.
Black Morocco.
Blue Damascus.
Gros Colman (Dodrelabi).
Babarossa.
Black Hamburg (Trollinger).
Howland's Black Hamburg.
Rose of Peru.
Flame Tokay.
Black Corinth.

AMERICAN TYPE—*Improved.*

Faith.
Cunningham.
Herbemont.
Lenoir.
Amber.
Rulander.
Walter.
Martha.
Diana.
Moore's Early.
Isabella regia.

American Hybrids with Vinifera.

Cornucopia.
Autuchon.

TYPES OF WILD VINES.

American.

V. cordifolia (Michaux).
V. æstivalis (Michaux).
V. riparia (Michaux).
V. labrusca (Linneus).
V. vulpina (Linneus).
V. rupestris (Scheele).
V. candicans (Engelm.).
V. Solonis (Engelm.).
V. Monticola (Buckley).
V. Berlandieri (Planchon).
V. Floridana (Munson).
V. rubra (Michaux).
V. Arizonica (Engelm.).
V. Californica (Bentham).
V. cinerea (Engelm.).
V. Doaniana (Munson).
V. bicolor (Le Conte).
V. coriacea (Shuttleworth).
V. Champini (Planchon).
V. Munsoniana (Simpson).
V. Simpsoni (Munson).

Asiatic.

V. vinifera from Caucasus.
V. Romaneti, two varieties.
Spinovitis Davidii, two varieties.

APPENDIX No. 5.

LIST OF HERBACEOUS PLANTS IN THE GARDEN OF ECONOMIC PLANTS AT BERKELEY.*

GRASSES (*Graminæ.*)

Japanese wheat grass, *Agropyrum Japonicum;* Japan.
Blue stem, *Agropyrum glaucum;* Colorado.
Bunch, *Agropyrum divergens;* Oregon and Washington.

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* Trees and shrubs surrounding the garden are included in the lists of arboretums. Common kitchen vegetables, of which the variety changes from year to year, are omitted from this enumeration, as also are a number of common flowering plants used merely for ornamentation. Some are mentioned on account of their climatic significance. All here mentioned are fully hardy at Berkeley.

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Blue joint, *Agropyrum tenerum.*
Red top, *Agrostis vulgaris;* Europe.
White bent, *Agrostis alba;* Europe.
Broad-leaved creeping bent, *Agrostis stolonifera;* England.
Tall oat, *Avena elatior;* Europe.
Wild oat, *Avena fatua;* Europe.
Meadow fox tail, *Alopecurus pratensis;* Europe.
Kangaroo, *Anthistiria ciliata;* Australia.
Schrader's brome, *Bromus Schraderi,* or *unioloides;* South America.
Hungarian brome, *Bromus inermis;* Europe.
Soft brome, *Bromus mollis;* Europe.
Sucksdorf brome, *Bromus Sucksdorfii.*
Hooker's brome, *Bromus Hookerianus.*
Grama, *Bonteloua oligostachya;* Colorado.
Bermuda, *Cynodon dactylon;* Europe.
Orchard, *Dactylis glomerata;* Europe.
Mountain blue joint, *Deyeuxia* sp.; Pacific slope.
Teosinte, *Euchlæna luxurians.*
Giant rye, *Elymus condensatus;* Pacific slope.
Indian millet, *Eriocoma cuspidata.*
Various-leaved fescue, *Festuca heterophylla;* Europe.
Meadow fescue, *Festuca elatior;* Europe.
Sheep's fescue, *Festuca ovina;* Europe.
Small fescue, *Festuca tenuifolia;* America.
Hard fescue, *Festuca duriuscula;* Europe.
Bunch, or mountain fescue, *Festuca gracillima.*
Fall bunch, or western fescue, *Festuca scabrella;* Pacific Slope.
Nit grass, *Gastridium australe.*
Soft meadow, *Holcus lanatus;* Europe.
Australian ray, *Lolium perenne,* var. *Australiense.*
Italian ray, *Lolium perenne,* var. *Italicum.*
Fall melic, *Melica altissima.*
Millet, *Milium multiflorum;* Old world.
Kentucky blue, *Poa pratensi;* Old world.
Texas blue, *Poa arachnifera.*
Northwestern blue, *Poa Nevadensis.*
Roughish meadow, *Poa trivialis.*
Timothy, *Phleum pratense;* Europe.
Mountain timothy, *Phleum,* sp.; Colorado.
Canary, *Phalaris Canariensis;* Europe.
Southern reed, or California timothy, *Phalaris intermedia;* United States.
Hairy-flowered paspalum, *Paspalum dilatatum;* America.
Louisiana grass, gazon, *Paspalum platycaule;* America.
Tallest panic, *Panicum altissimum.*
Bulbous panic, *Panicum bulbosum;* Arizona.
Hair-stalked panic, *Panicum capillare;* America.
Indian, or wood, *Sorghum Nutans.*
Evergreen millet, or Johnson, *Sorghum Halepense.*
St. Augustine, *Stenotaphron Americanum.*
Large panicled vilfa, *Sporobolus cryptandrus.*
Feather bunch, *Stipa viridula.*
Sorghums in variety, *Sorghum vulgare.*

Leguminous Forage Plants (Clovers, etc.).

Horn-pod clover, *Anthyllis vulneraria;* Europe.
Sylla, *Hedysarum coronarium;* South Europe.
Japan clover, *Lespedeza striata.*
Tangier pea, *Lathyrus tingitanus.*
Red birdsfoot, *Lotus tetragonolobus.*
Yellow treefoil, *Medicago lupulina.*
Alfalfa, *Medicago sativa.*
Snail clover, *Medicago turbinata.*
White melilot, or Bokhara clover, *Melilotus albus.*
Seradella, *Ornithopus sativus.*
Sainfoin, or Esparcet, *Onobrychis sativa.*
Red clover, *Trifolium pratense.*
White clover, *Trifolium repens.*
Scarlet clover, *Trifolium incarnatum.*
Swedish clover, *Trifolium hybridum.*
Strawberry clover, *Trifolium fragiferum.*
California clover, *Trifolium involucratum.*
California clover, *Trifolium tridentatum.*
Hairy vetch, *Vicia villosa.*
Common vetch, *Vicia sativa.*
Worm clover, *Scorpiurus sulcatus.*

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Forage Plants—Miscellaneous.

Comfrey, *Symphytum asperrimum.*
Salt bushes, *Atriplex* sp. and *Kochia* sp.
Tagasaste, *Cytisus proliferus albus.*
Jersey kale, *Brassica* sp.

Textile Plants.

New Zealand flax, *Phormium tenax.*
Ramie, *Boehmeria nivea* and *tenacissima.*
Jute, *Corchorus textilis.*
Esparto grasses, *Stepa tenacissima* and *Lygeum sparteum.*
African grass (Diss), *Festuca altissima.*
Century plant, *Agave Americana.*
Fiber flax—White-flowering from France, Royal from Germany, Russian from Pskoff, and Yellow-seeded, *Linum usitatissimum.*

Aromatic Herbs.

Sweet fennel, *Foeniculum officinale.*
Coriander, *Coriandrum sativum.*
Dill, *Anethum graveolens.*
Caraway, *Carum carvi.*
Long-flowered catnip, *Nepeta grandiflora.*
Common catnip, *Nepeta cataria.*
Lorage, *Levisticum officinale.*
Tansy, *Tanacetum vulgare.*
Summer savory, *Satureia hortensis.*
Cummin, *Cuminum cyminum.*
Anise, *Pimpinella anisum.*
Hoarhound, *Marrubium vulgare.*
Sweet majoram, *Origanum majorana.*
Wormwood, *Artemisia absinthium.*
Rue, *Ruta graveolens.*
Lavender, *Lavandula vera.*
Bush basil, *Ocimum basilicum.*
Balm, *Melissa officinalis.*
Sage, *Salvia officinalis.*
Spear mint, *Mentha viridis.*
Crisp-leaved mint, *Mentha crispa.*
Wild bergamot, *Monarda fistulosa.*
Common thyme, *Thymus vulgaris.*
Balm of Gilead, *Dracocephalum Canariense.*

Medicinal Plants.

Yellow chamomile, *Anthemis tinctoria.*
German chamomile, *Matricaria chamomilla.*
Roman chamomile, *Anthemis nobilis.*
Arnica, *Arnica Montana.*
Comfrey, *Symphytum officinale.*
Valerian, *Valeriana officinalis.*
Sea lavender, *Statice limonum.*
Ginger, *Zingiber officinale.*
Black henbane, *Hyoscyamus niger.*
Rattlesnake weed, *Daucus pusillus.*
Poison lettuce, *Lactuca virosa.*
Marsh mallow, *Althea officinalis.*
High mallow, *Malva rotundifolia.*
Common mallow, *Malva vulgaris.*
Fetid clary sage, *Salvia sclariola.*
Poison lettuce, *Lactuca scariola.*
Poison lettuce, *Lactuca angustata.*
Hedge nettle, *Stachys affinis.*
Jamestonn weed, *Datura stramonium.*
Poison hemlock, *Conium maculatum.*
Hollyhock, *Althea rosea.*
False indigo, *Baptisia Australis.*
Great blue lobelia, *Lobelia syphilitica.*
Indian tobacco, *Lobelia inflata.*
Para cress, *Spilanthes oleracea.*
Meadow sweet, *Spiræa ulmaria.*
California golden rod, *Solidago Californica.*
Celandine, *Chelidonium majus.*
Red pepper, *Capsicum annuum.*

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Belladonna, *Atropa belladonna.*
Yellow melilot, *Melilotus officinalis.*
Foxglove, *Digitalis purpurea.*
Foxglove, *Digitalis alba.*
Mullein, *Verbascum thapsus.*
Black mullein, *Verbascum nigrum.*
Avens, *Geum urbanum.*
Liquorice, *Glycyrrhiza echinata.*
Liquorice, *Glycyrrhiza glabra.*
Fenugreek, *Trigonella foenum graecum.*
Jacob's ladder, *Polemonium grandiflorum.*
Giant spurge, *Euphorbia lathyris.*
White Mexican poppy, *Argemone Mexicana.*
Opium poppy, *Papaver somniferum.*
Long-leaved tobacco, *Nicotiana longifolia.*
Japanese anemone, *Anemone Japonica.*
Soapwort, *Saponaria officinalis.*
Milk weed, *Asclepias Douglassii.*
St. John's wort, *Hypericum perforatum.*
Borage, *Borrago officinalis.*
Ginseng, *Panax quinquefolium.*
False saffron, *Carthamus tinctorius.*
Gum plant, *Grindelia robusta.*
Chili cajote Calabazita, *Cucurbita perennis.*
Squills, *Scilla officinalis.*
Indian hemp, *Tricerastes glomerata.*
Aspodel, *Asphodelus floribundus.*
Asphodel, *Asphodelus luteus.*
Panque, *Gunnera scabra.*
Sweet flag, *Acorus calamus.*

MISCELLANEOUS PLANTS.

Cañaigre, *Rumex hymenosepalus.*
Lemon grass of India, *Cymbopogon schoenanthus.*
Taro, or Tanja, *Colocasia antiquorum*, var. *esculentum.*
Chinese yam, *Dioscorea batatas.*
Earth almond, *Cyperus esculentus.*
Chicory, *Cichorium intybus.*
Edible oxalis, *Oxalis crenata.*
Sunflower, *Helianthus Californicus.*
Russian sunflower, *Helianthus annuus.*
Artichoke, *Cynara scolymus.*
Cardoon artichoke, *Cynara cardunculus.*
Madder, *Rubia tinctoria.*
Oil radish, *Raphanus oleiferus.*
Rape, *Brassica campestris.*
Peanut, *Arachis hypogæa.*
Castor bean, *Ricinus officinalis.*
Chapman's honey plant, *Echinops sphærocephalus.*
Dalmation insect powder plant, *Pyrethrum cinerariæfolium.*
Red insect powder plant, *Pyrethrum roseum.*
Fuller's teasel, *Dipsacus fullonum.*
Classic acanthus { *Acanthus mollis.* / *Acanthus spinosus.* / *Acanthus longifolius.*
Scarlet larkspur, *Delphinium cardinale.*
Œnothera taraxacifolia.
Canterbury bells { *Campanula media.* / *Campanula nobilis.*
Platycodon grandiflorum.
Salvia patens.
Eryngium pandanifolium.
Hypericum sp.
Ophiopogon Japonicum.
Yellow flax, *Linum flavum.*
Iris Kæmpferi.
Heuchera coccinea.
Vancouveria hexandra.
Mayflower, *Convallaria majalis.*
Funkia cordata.
Day lily, *Hemerocallis fulva.*
Fragrant cleavers, *Asperula odorata.*
California datura, *Datura meteloides.*

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APPENDIX No. 6.

AGRICULTURAL EXPERIMENT STATIONS IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

To receipts from Treasurer of the United States as per appropriation for year ending June 30, 1889, under Act of Congress, approved March 2, 1887			$15,000 00
June 30, 1889—By buildings		$736 70	
By chemical apparatus and supplies		910 68	
By furniture		1,801 34	
By fencing and drainage		203 82	
By freight and expressage		384 63	
By incidental expenses		121 36	
By labor		3,196 41	
By live stock		765 25	
By postage and stationery		274 38	
By printing		31 50	
By salaries		1,749 99	
By supplies		2,451 59	
By scientific instruments		85 94	
By tools, implements, and machinery		1,396 74	
By traveling		227 15	
By water supply		662 52	
			$15,000 00

We, the undersigned, duly appointed members of the Finance Committee of the University of California, do hereby certify that we have examined the books and accounts of the experiment stations of the University of California for the fiscal year ending June 30, 1889; that we have found the same well kept and correctly classified as above, and that the receipts for the time named are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
HORATIO STEBBINS,
GEORGE T. MARYE,
Finance Committee of the Board of Regents, University of California.

I hereby certify that the foregoing statement, to which this is attached, is a true copy from the books of account of the institution named.

J. H. C. BONTÉ,
Secretary of the Board of Regents.

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ERRATA IN LISTS OF PLANTS.

Page 173, under TAMARISCINEÆ, after *Fouquiera splendens*, read hh.
Page 174, under RHAMNEÆ, after *Rhamnus Californica*, read California buckthorn, Cascara sagrada in part.
Page 174, under same, after *Ceanothus sorediatus*, read California lilac.
Page 174, under SAPINDACEÆ, after *Æsculus Californica*, read California buckeye.
Page 174, under same, after *Acer campestre*, read European elm.
Page 174, under same, after *Negundo Californicum*, read California box elder.
Page 174, under LEGUMINOSÆ, second line, for *junieum*, read *junceum*.
Page 175, under ROSACEÆ, after *Rosa gymnocarpa* and *Rosa Californica*, add Wild rose.
Page 175, tenth line from below, for *Caccata*, read *baccata*.
Page 177, twelfth line from above, after *Ribes Californicum*, read l.
Page 177, twenty-second line from above, for *Liquidamber*, read *Liquidambar*.
Page 177, under CAPRIFOLIACEÆ, after *Viburnum tinus*, read Laurustinus.
Page 177, under same, after *Symboricarpus racemosus*, read Waxberry.
Page 177, under same, for *Louicera*, read *Lonicera*.
Page 177, under RUBIACEÆ, after *Galium Nuttallii*, read Woody cleavers.
Page 178, lines five, six, seven, and eight from top, for *Dyopyrus*, read *Diospyros*.
Page 179, middle of page, for *Deeringia*, read *Deeringia*.
Page 179, under EUPHORBIACEÆ, fourth line, for *pulchenima*, read *pulcherrima*.
Page 179, under URTICACEÆ, last line, for *auantiaca*, read *aurantiaca*.
Page 180, under BETULACEÆ, after *Alnus rubra* and *Alnus rhombifolia*, read Alder.
Page 181, thirty-first line from above, for Deodaro, read Deodar.
Page 181, after *Dracaena Cannaefolia* and *Dracaena terminalis*, read Dragon tree.
Page 182, seventh line from above, for Grass smilax tree of Australia, read Grass tree of Australia.
Page 184, under PEARS, No. 59, for Berry, read Berri.
Page 184, under same, No. 33, for Paradise, read Paradis.
Page 184, under CHERRIES, No. 12, for Riverchon, read Reverchon.
Page 184, under same, No. 13, Mervelle, read Merveille
Page 185, No. 134, for Noöl, read Noël.
Page 186, No. 131, for Borsdoffer, read Borsdorffer.
Page 186, No. 132, for Challotten Thaler, read Charlottenthaler.
Page 192, middle of page, for Sargent, read Sergent.

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AGRICULTURAL EXPERIMENT STATION.

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REPORT OF WORK

OF THE

AGRICULTURAL EXPERIMENT STATIONS

OF THE

UNIVERSITY OF CALIFORNIA,

For the Year 1890.

BY E. W. HILGARD,
Professor of Agriculture and Director of the Stations.

BEING A PART OF THE REPORT OF THE REGENTS OF THE UNIVERSITY.

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REPORT OF THE PROFESSOR OF AGRICULTURE AND DIRECTOR OF THE EXPERIMENT STATIONS

TO THE

PRESIDENT OF THE UNIVERSITY.

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LETTER OF TRANSMITTAL.

Prof. MARTIN KELLOGG, *Acting President of the University:*

SIR: I transmit herewith a report on the work of the Experiment Station of the University, including that of the culture sub-stations established under the provisions of the "Hatch Act" of endowment.

In the regular order of events this report should represent the work of the year 1890. Owing, however, to the difficulties and delays brought about by lack of an adequate *personnel* in the staff, and the extraordinary duties imposed upon the Director in the establishment of new culture sub-stations, it has been impossible to keep pace, in the publication of the annual reports, with the actual progress of the work. Hence, the present document contains the record of some work dating back as far as 1888, and thus far published only in bulletin form; and at the same time, owing to the lateness of the date at which it becomes possible to send this manuscript to press, it has seemed inadvisable to defer further the publication, in permanent form, of important material now on hand, but actually elaborated within the season of 1891. As a matter of fact, therefore, this report clears our docket of work done up to June 30, 1891, and not thus far published save partially in bulletin form, excepting only the viticultural work, which for palpable reasons is best published separately, as has been done heretofore. A report on this latter subject, prepared largely by Assistant Paparelli, will therefore follow the present one within a short time, and will similarly clear our docket up to the vintage of 1890, of which only a partial report can, in the nature of the case, as yet be made.

The increase lately made in the staff of the station, on the basis of the "College Aid Fund" provided at the last session of Congress, will render it possible to publish reports with regularity hereafter, so far as can be foreseen. It will always, however, be preferable to sacrifice the shadow to the substance, and to give publicity to subjects of immediate interest to the agricultural population whenever such matter shall be ready for the press. To do this in the definitive form of a final report would usually delay such publication to an undesirable extent; it is, therefore, intended to continue, as heretofore, the issuance of "bulletins" in transient form, which are to be reproduced, with more elaborate discussion when desirable, in the annual reports.

As regards the chemical work here reported, except where otherwise noted, that relating to soils, waters, and other mineral substances, as well as fertilizers, also that relating to ramie, beets, and greasewood, has been done by Assistant M. E. Jaffa; while all relating to fruits, and especially the analyses of musts and wines (separately reported upon hereafter) has been done by, or under the charge of, Assistant George E. Colby.

The arrangement and last revision of the body of the present report for the press has been in the experienced and efficient hands of Assistant Prof. R. H. Loughridge, whose former work in the report on cotton

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production for the Tenth Census, vouches for his qualifications in the direction in which additional aid was most needed in this office. In the preparation of the entomological portion of the report, Assistant C. W. Woodworth has made important contributions, and we look forward with confidence to a material development of the entomological work of the station under his hands, already well trained and proved in former fields.

The wide and unusual scope taken by our station work is well illustrated in the present report. The large extent of territory, and the equally wide climatic range requiring our attention; the questions of immediate vital interest newly arising under unusual and imperfectly known conditions, necessarily impart to our work an aspect entirely different from that borne by the record of the stations whose work is thrown within the well-traced lines of climates akin to those of western Europe and the Atlantic States, where most of the theoretical investigation relating to agriculture has thus far been done, and laid down in standard publications. We cannot accept unquestioningly, for California, many of the maxims that have gained unhesitating assent in those regions, but whose application to arid climates has never had opportunity to be tested. The unfamiliar agricultural practice of South Spain, Egypt, North Africa, Asia Minor, and the northwest provinces of India, rather than that of the eastern United States, forms the basis upon which the greater part of California must build its own, profoundly modifying many of the current practices of the older States. The incredulity with which so many of the most familiar and daily occurring phenomena of Californian agriculture meet at the East (not uncommonly to the extent of being characterized as "another California yarn"), admonish us that our line of investigation is necessarily laid in different and new directions; and that while we should sedulously avail ourselves of every possible source of information afforded by Old World and Eastern practice, yet to follow such precedents blindly and without careful consideration of the characteristic differences induced by climatic influences, would be to court failure in the majority of cases.

If, therefore, Eastern or European readers should find the substance of this and of former reports of a rather miscellaneous and elementary character, and largely devoid of connected and systematic investigation, such as forms the subject of station work elsewhere, let it be remembered that California is not only a new country in the sense of comparatively late occupation by a progressive population, but that it also contains so much that is intrinsically new to scientific and technical investigation; that the problems to be solved by the experiment station are correspondingly new and untried, and must be dealt with accordingly.

E. W. HILGARD,
Director of Experiment Stations.

BERKELEY, July, 1891.

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EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA.

CENTRAL STATION (Berkeley, Alameda County).

(NOTE.—All station officers participate in University instruction.)

E. W. HILGARD, Ph.D., LL.D. (Professor of Agriculture), Director and Chemist.
E. J. WICKSON, M.A. (Associate Professor of Agriculture, Horticulture, and Entomology), Superintendent of Agricultural Grounds.
E. L. GREENE, Ph.B. (Associate Professor of Botany), Botanist.
R. H. LOUGHRIDGE, Ph.D. (Assistant Professor), Agricultural Geologist and Agricultural Chemist.
M. E. JAFFA, Ph.B. (Instructor), First Assistant Chemist in Agricultural Laboratory.
L. PAPARELLI, Lic.Agr. (Instructor), Assistant in charge of Viticulture and Olive Culture.
GEORGE E. COLBY, Ph.B. (Instructor), Second Assistant Chemist in Viticultural Laboratory.
C. W. WOODWORTH, M.S. (Instructor), Assistant in Entomology.
W. G. KLEE (deceased), Inspector of Stations, to October 20, 1890.
C. H. SHINN, A.B., Inspector of Stations, from October 20, 1890.
EMIL KELLNER, Foreman of Station Grounds.
F. T. BIOLETTI, Foreman of the Viticultural Cellar.
E. F. GOODYEAR, Clerk to the Director (resigned June 30, 1891).
J. W. BLANKENSHIP, A.B., Clerk to the Director, from July 1, 1891.

SIERRA FOOTHILL STATION (near Jackson, Amador County).

A. CAMINETTI, Patron; Jackson (term expired June 30, 1891).
R. C. RUST, Patron; Jackson (appointed July 1, 1891).
GEORGE HANSEN, Foreman; Jackson.

SOUTHERN COAST RANGE STATION (near Paso de Robles, San Luis Obispo County).

J. V. WEBSTER, Patron; Creston.
R. D. CRUICKSHANK, Foreman; Paso Robles.

SAN JOAQUIN VALLEY STATION (near Tulare City, Tulare County).

B. F. MOORE, Patron; Tulare.
JULIUS FORRER, Foreman; Tulare.

SOUTH CALIFORNIA STATION (near Pomona, Los Angeles County).

RICHARD GIRD, Patron; Chino.
K. MCLENNAN, Foreman; Pomona.

VITICULTURAL STATIONS (under private auspices).

WEST SIDE SANTA CLARA VALLEY STATION; Cupertino, Santa Clara County. John T. Doyle, Patron; Menlo Park.
EAST SIDE SANTA CLARA VALLEY STATION; Mission San José, Alameda County. John Gallegos, Patron; Mission San José.
FRESNO VALLEY STATION; Fresno City, Fresno County. E. B. Rogers, Patron; Fresno.

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I.

RECORD AND DISCUSSIONS OF WORK IN THE GENERAL AGRICULTURAL LABORATORY.

EXAMINATIONS AND ANALYSES OF SOILS, WATERS, FRUITS, ALKALI, AND MISCELLANEOUS SUBSTANCES.

I. ANALYSES OF SOILS.

A. SIERRA FOOTHILLS.

Soils from the Foothill Experiment Station.

No. 1291. Soil from manzanita land, McKay tract, Foothill Station, Amador County; from the level, or gently sloping portion of the land beyond (west of) the Amador ditch, at the foot of a granite ridge. The land is covered thickly with large bushes of manzanita and spiny chaparral, with tufts of grass in open spaces. The soil is a fawn-colored, coarse, gritty loam; dry lumps crush easily, showing much coarse, angular sand, mainly granitic debris.

No. 1294. Soil from pine land, McKay tract, from lower slope of residence hill toward the ditch, overgrown with young pine and some manzanita bushes. A reddish, coarse, gritty loam, dry lumps crushing easily, becoming but slightly plastic on wetting and kneading, and showing much mica. The coarse part consists mainly of sharp quartz sand and larger quartz fragments, evidently derived from veins in the "bedrock;" also, more or less rounded fragments of a sandy, micaceous shale or slate, often rusty; little or no feldspar.

For comparison, two other soils of the station, already reported, are placed alongside.

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Soils from the Foothill Station.

	No. 1291. Soil from Manzanita Land.		No. 1294. Soil from Pine Land.		No. 1115. Granite Soil, North Slope.		No. 1113. Slate Soil, South Slope.	
Coarse materials >0.5mm	52.00		23.00		40.00		19.20	
Fine earth	48.00		77.00		60.00		80.80	
	100.00		100.00		100.00		100.00	
Analysis of Fine Earth.								
Insoluble matter	72.43	81.37	73.52	79.77	62.44	73.95	49.96	64.92
Soluble silica	8.94		6.25		11.51		14.96	
Potash (K_2O)	.64		.26		.53		1.48	
Soda (Na_2O)	.09		.07		.18		.43	
Lime (CaO)	.20		.17		.50		.60	
Magnesia (MgO)	.18		.16		.30		2.21	
Br. ox. of manganese (Mn_3O_4)	.03		.04		.04		.05	
Peroxide of iron (Fe_2O_3)	4.19		4.67		5.28		11.52	
Alumina (Al_2O_3)	8.63		9.35		12.18		12.31	
Phosphoric acid (P_2O_5)	.05		.07		.05		.05	
Sulphuric acid (SO_3)	.01		.01		.01		.02	
Water and organic matter	4.89		5.24		7.28		6.63	
Totals	100.28		99.81		100.30		100.22	
Humus	.412		.392		.48		.54	
Ash	.518		.358		.23		.80	
Sol. phosphoric acid	.020		.018		.02		.03	
Silica	.240		.130		.16		.60	
Hygroscopic moisture (absorbed at 15° C.)	2.56		3.14		5.93		5.74	

The above table shows very wide differences in the composition of the soils of the station in its several portions. All agree in having but a moderate supply of phosphoric acid; but in potash they range all the way from .26 to 1.48 per cent; in lime from .17 to .60 per cent (in the subsoil of No. 1113, 1.37 per cent). It is thus no wonder that without a close examination of the soils to be used, agricultural ventures in the foothills are sometimes disappointing; both because of great differences in the nature of the soils within small distances, and of the variations in depth. In addition, the so called granites differ so widely in their mineral nature that what is true of one "granite soil" may not be at all true of another in a different region.

Of the two soils here specially in question, it appears that they constitute the poorest portion of the station tract; and hence the fertilizer experiments made upon them this year (1891) will be of more than usual interest, it being currently stated that they do not yield, at best, more than one and a quarter to one and a half tons of hay per acre, and in unfavorable years much less. The kind of fertilizer wanted on them will probably be found to be of the most complete type—that of stable manure.

No. 1139. Red soil of the foothills, Sec. 7, T. 17 N., R. 14 E., near Moore's Station, on the Oroville road, Butte County; sent by Mr. Norman Rideout, Marysville. The sample was taken twelve inches deep.

"The soil is taken from a hillside in the foothills, on the east side of the Sacramento Valley, at an elevation of about five hundred feet above the level of the sea. The soil is covered with a short grass which, during the winter and spring, affords an excellent pasture; and in this neighborhood such land is generally used for this purpose only. It is

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well covered with trees, consisting of white oak, with an occasional digger pine. The soil, when plowed and exposed to the sun and air, assumes a bright red color, which becomes darker with cultivation. It packs quickly, but this difficulty seems to be overcome by repeated plowing. The soil is deep, and it is difficult to distinguish any subsoil; however, there seems to be more gravel at the surface. The average rainfall is twenty inches. Attention is being directed to this land as suitable for the vine, olive, and fig. Large numbers of trees and vines have been planted, and, with irrigation, appear to be doing well. The sample is a fair average one of a soil covering thousands of acres in the foothills, on the eastern border of the Sacramento Valley."

A cinnamon-colored, silty loam. The dry lumps crush pretty easily between the fingers, soften quickly on wetting, without greatly darkening in color, and become only moderately plastic on kneading. The soil will evidently till kindly, save when *very* wet. It contains some coarse sand and (mostly angular) gravel up to one fourth inch diameter, consisting partly of white quartz, but mostly of gray sandstone, and other sandy varieties of the foothill "bedrock." It does not effervesce with acids.

The analysis resulted as follows:

Red Lands near Moore's Station, Butte County.

	No. 1139. Red Soil.	
Coarse materials >0.5mm	35.00	
Fine earth	65.00	
Analysis of Fine Earth.		
Insoluble matter	47.27	65.54
Soluble silica	18.27	
Potash (K_2O)	.26	
Soda (Na_2O)	.05	
Lime (CaO)	6.10	
Magnesia (MgO)	1.23	
Br. ox. of manganese (Mn_3O_4)	.03	
Peroxide of iron (Fe_2O_3)	9.84	
Alumina (Al_2O_3)	12.35	
Phosphoric acid (P_2O_5)	.07	
Sulphuric acid (SO_3)	.01	
Water and organic matter	4.42	
Total	99.90	
Humus	.35	
Ash	.44	
Sol. phosphoric acid	.03	
Silica	.28	
Hygroscopic moisture (absorbed at 15°C.)	4.00	

The analysis shows this soil to be quite poor in potash and humus, but with a fair proportion of phosphoric acid, and a large one of lime; the latter substance, however, is not in the form of carbonate to any great extent, but, as shown in the higher proportion of soluble silica in this and other foothill soils, in that of an easily decomposable complex silicate. The soil is thus not a very thrifty one, and would soon be exhausted by field crops, but where deep enough will doubtless do well for fruits, especially peaches, almonds, cherries, citrus fruits, and others requiring light and well drained soils. For citrus fruits and grapes it would soon require fertilization with potash salts, and, ultimately, with complete fertilizers. Its low content of humus should, as soon as possi-

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ble, be increased by green-manuring, or, if fruits should prove undersize, by the use of Chile saltpeter or other nitrogenous fertilizers.

Nos. 1027, 1028. Red soil and subsoil, from eight miles west of Anderson, Shasta County; sent by Mr. J. R. Love, Anderson. The dry lumps crush readily between the fingers, and when wet are of a dark red color, and plastic to some extent. The difference between the soil and its subsoil seems to be chiefly in the organic matter, which gives to the soil a darker color; the humus and its available constituents were therefore alone determined in the soil, and a full analysis given to the subsoil.

Red Land west of Anderson, Shasta County.

	No. 1028. Red Subsoil.		No. 1027. Red Soil.
Coarse materials > 0.5mm	23.3		
Fine earth	76.7		
	100.0		
Analysis of Fine Earth.			
Insoluble matter	51.893	69.741	
Soluble silica	17.848		
Potash (K_2O)	.273		
Soda (Na_2O)	.162		
Lime (CaO)	.113		
Magnesia (MgO)	.306		
Br. ox. of manganese (Mn_3O_4)	.026		
Peroxide of iron (Fe_2O_3)	6.979		
Alumina (Al_2O_3)	15.801		
Phosphoric acid (P_2O_5)	.041		
Sulphuric acid (SO_3)	.033		
Water and organic matter	7.447		
Total	100.922		
Hygroscopic moisture (absorbed at 15° C.)	8.347		8.000
Humus			1.614
Ash			.328
Soluble phosphoric acid			.020

This soil is rather unusual in composition for California, and would readily be taken, in its chemical composition, for one of the "Pine Hill" soils of the Cotton States. Its supply of lime is the lowest thus far found in any soil of this State, and would be deficient anywhere; phosphoric acid and potash are also in low supply, and considering the poverty in lime, this soil cannot be considered as likely to produce for more than a few years without substantial fertilization. The large percentage of alumina is evidently due to the presence of "clay," but the latter is not in a plastic condition, but probably in that of kaolin or porcelain earth—a poor foundation for a soil.

So long as so much good land can be had in the State, few will care to cast their lot on such land as this.

No. 1179. Soils from the east side of Honey Lake, Lassen County; sent by W. A. Clark, Berkeley. The samples were taken twelve inches deep, and represent a district of thirty square miles more or less accurately. They are whitish, silty, effervescent with acid, becoming somewhat plastic on wetting, without darkening much in color. The coarser parts are sharply angular, apparently fragments of obsidian (volcanic glass) and pumice stone, with some quartz. All the samples appear to be ancient lake deposits. Only one was chemically examined.

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Soil from Honey Lake, Lassen County.

	No. 1179. East Side of Lake.
Potash	.85
Soda	.49
Lime (8.54 carbonate of lime)	4.78
Phosphoric acid	.12
Sulphuric acid	.03

These data show the soil to be highly calcareous, and rich both in potash and phosphoric acid. All are evidently poor in humus, and in the absence of definite information regarding the vegetation of the lands, it is difficult to judge how far they would be productive in cultivation without the addition of vegetable matter. So far as the mineral ingredients are concerned they promise well, although the large proportion of soda found indicates the presence of some "alkali." Much will, of course, depend upon the nature of the subsoil, which, in some of these lands, is known to be extremely sandy, and of little promise. Such tracts are usually marked by an exclusive growth of greasewood; the addition of gray sage to this vegetation always proves the presence of a more substantial subsoil, which is of particular importance in lands to be irrigated.

B. GREAT VALLEY.

No. 1192. Soil from the land of the Buhach Colony, Merced; sent by McSwain & Co., Merced. The soil is a sandy loam, somewhat dark when dry. Its subsoil is much lighter in color, and closely resembles the under-subsoil, an analysis of which is given below. The soil sample was taken to a depth of six inches.

No. 1194. Under-subsoil of the above; taken at a depth of from thirty to fifty-four inches. It is light gray in color when dry, very sandy.

Valley Land, Buhach Colony, Merced.

	No. 1192. Soil.		No. 1194. Under-subsoil.	
Coarse materials $>0.5^{mm}$	35.00		30.00	
Fine earth	65.00		70.00	
Analysis of Fine Earth.				
Insoluble matter	90.30	92.67	88.69	91.25
Soluble silica	2.37		2.56	
Potash (K_2O)	.26		.25	
Soda (Na_2O)	.08		.06	
Lime (CaO)	.49		.41	
Magnesia (MgO)	.33		.34	
Br. ox. of manganese (Mn_3O_4)	.03		.03	
Peroxide of iron (Fe_2O_3)	3.32		3.67	
Alumina (Al_2O_3)	1.87		2.95	
Phosphoric acid (P_2O_5)	.03		.03	
Sulphuric acid (SO_3)	.03		.02	
Water and organic matter	1.27		.87	
Totals	100.38		99.88	
Humus	.29			
Ash	.34			
Sol. phosphoric acid	.02			
Silica	.17			
Hygroscopic moisture (absorbed at 15° C.)	1.08		1.28	

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These soils are extremely sandy, and at first sight would seem to correspond with the sandhill soils of the Fresno neighborhood. But examination shows that the sand of the Merced soils is very largely granitic, and, correspondingly, the analysis shows higher proportions of mineral plant-food, and, therefore, a better promise of durability. It will be observed that there is no notable difference between the subsoil at four and one half feet depth and the surface soil; the former is slightly heavier and more retentive. Considering the great depth and perviousness of the soil and subsoil, the low plant-food percentages need not discourage cultivation, so long as the level of the bottom-water is not allowed to rise too near the surface; but to fill up this land with water from below will be just as fatal to its production as it has been to that of the sandier class of soils near Fresno. The application of manures, when called for, will require careful management, as fresh stable manure would not decay, and therefore would remain ineffective, unless put in very deeply; while soluble fertilizers would very readily be washed out of reach of the roots of crops by heavy rains, or irrigation.

No. 1061. *Soil* of viticultural experimental plot for grafting; E. B. Rogers' place, Fresno. The sample was taken twelve inches deep. This is a coarsely sandy, reddish soil, showing an abundance of angular granitic ingredients; some little angular as well as partly rounded gravel, as much as eight mm. in diameter. The dry lumps crush easily between the fingers; on wetting they soften quickly and become slightly plastic; but the soil should be workable at all times. When dry the color is reddish brown, mottled with white grains; wetting heightens the reddish tint.

No. 1063. *Subsoil* of the above; taken from twenty-four to thirty-six inches depth. A brownish, sandy, lumpy mass, almost a hard pan, probably from sampling while wet. The dry lumps do not crush readily between the fingers, but soften instantly on wetting and become fairly plastic. This substratum manifestly contains more clay than the surface soil, for which it makes a very substantial foundation; it contains less of coarse and gravelly ingredients than the soil.

No. 1065. *Subsoil* of land offered for an experimental plot on Dr. Eschleman's place, three miles east of Fresno. The sample was taken from twelve to twenty-four inches depth. It does not differ materially from the soil in any respect, save in a slightly lighter color. The soil is a very sandy loam, somewhat coarse, and showing many white grains of one and two mm. diameter, which, under the microscope, are shown to be quartz and feldspar. The dry lumps are somewhat coherent, but are readily crushed between the fingers; the soil is barely plastic on wetting.

No. 1066. *Under-subsoil* of the above; Dr. Eschleman's place. Taken at a depth of four to four and a half feet. The earth is very similar to the surface soil, save as to a still lighter tint and slightly greater coarseness.

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Valley Land of Experimental Plots, near Fresno.

	E. B. Rogers' Place.		Dr. Eschleman's Place.	
	Soil. No. 1061.	Subsoil. No. 1063.	Subsoil. No. 1065.	Under-subsoil. No. 1066.
Coarse materials >0.5mm	44.5	25.5	14.5	15.35
Fine earth	55.5	74.5	85.5	84.65
	100.0	100.0	100.0	100.00
Analysis of Fine Earth.				
Insoluble matter	73.511	69.170	83.30	85.56
Soluble silica	11.289 84.800	13.498 82.668	6.31 89.61	3.70 89.26
Potash (K_2O)	.418	.654	.29	.35
Soda (Na_2O)	.530	.762	.47	.26
Lime (CaO)	1.417	.975	1.02	1.00
Magnesia (MgO)	1.955	2.881	.63	.71
Br.ox.of manganese (Mn_3O_4)	.068	.157	.05	.02
Peroxide of iron (Fe_2O_3)	4.995	5.178	2.70	3.57
Alumina (Al_2O_3)	4.268	5.122	4.27	3.67
Phosphoric acid (P_2O_5)	.028	.040	.02	.04
Sulphuric acid (SO_3)	.016	.025	.01	.02
Water and organic matter	1.864	2.239	1.00	1.06
Totals	100.359	100.701	100.07	99.96
Humus	.281			.08
Ash	.082			.10
Sol. phosphoric acid	.004			
Hygroscopic moisture	2.21	4.07	1.41	1.31
Absorbed at	15° C.	15° C.	16° C.	15° C.

It will be noted that these two soils, and their subsoils, differ as materially in their composition as in their aspect. The reddish soil of Rogers' place is very much more substantial than that from the Eschleman tract, which appears to have been originally a sandy wash, lying a good deal lower than the reddish soil. The latter is manifestly derived directly from the Sierra granite, which, as the high percentage of "soluble silica" shows, has been to a large extent disintegrated into more soluble forms; and while both soils alike are fairly calcareous, the red soil is richer in potash, and possesses a substantial subsoil that retains moisture well, a quality in which the soil of the lower ground is notably deficient. Both are rather poor in phosphates, and there can be no doubt that this deficiency will be the first to be felt, and require to be dealt with as cultivation progresses. Both soils also are poor in humus, and should be supplied with vegetable matter for greater retentiveness and better supply of nitrogen. Their great depth and perviousness of course makes up for the relatively low supplies of plant-food in these soils, so long as the water-level is kept below the reach of the roots.

No. 1055. Red soil of Fresno Plains, Sec. 9, T. 14 S., R. 19 E., nine miles west of Fresno; from M. Theo. Kearney's "Fruitvale" tract. Taken to a depth of twenty-four inches. The soil is quite sandy, reddish when moist, and grayish brown when dry; could be tilled at all times. It contains visible white specks of potash feldspar (orthoclase); at some points these are very abundant and large. On washing the soil yields about 65 per cent of materials coarser than one mm. hydraulic value, glistening with black and golden mica (biotite), and containing a large amount of coarse quartz and orthoclase (apparently no plagio-

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clase). This tract is free from "hog-wallows," and bears the usual "plains" vegetation. It lies north of the Fresno "white ash" lands, toward the San Joaquin River; the "white ash" soil is doubtless connected with the Kings River drainage, the other with that of the San Joaquin River.

Land of Fresno Plains, "Fruitvale" Tract.

	No. 1055. Red Soil.	
Coarse materials >0.5mm	9.00	
Fine earth	91.00	
	100.00	
Analysis of Fine Earth.		
Insoluble matter	67.34	78.91
Soluble silica	11.57	
Potash (K_2O)	.82	
Soda (Na_2O)	.20	
Lime (CaO)	1.14	
Magnesia (MgO)	1.58	
Br. ox. of manganese (Mn_3O_4)	.02	
Peroxide of iron (Fe_2O_3)	7.51	
Alumina (Al_2O_3)	6.30	
Phosphoric acid (P_2O_5)	.07	
Sulphuric acid (SO_3)	.01	
Water and organic matter	3.28	
Total	99.84	
Humus	.39	
Ash	.23	
Sol. phosphoric acid	.03	
Silica	.17	
Hygroscopic moisture (absorbed at 15° C.)	3.62	

It will be seen that this soil differs quite materially from all the soils of the immediate neighborhood of Fresno thus far examined, the only point of agreement being a similar proportion of lime. But it is materially richer in both potash and phosphoric acid, and in its general composition is exceedingly like the lands of the Mussel Slough region in Tulare County, differing from the latter only in containing a little more iron. It will no doubt prove similarly productive when irrigated, and will be less subject to the invasion of alkali. Its supply of humus is not high, and hence, on cultivation, the addition of vegetable matter by green-manuring, or the use of nitrogenous fertilizers, would probably be first called for.

No. 1189. *Soil* from Sec. 17, T. 12 S., R. 17 E., near Madera, Fresno County; sent by Mr. John Brown, Madera. This is a gray, silty soil, full of glistening mica scales and fine sand. It darkens a little on wetting, and becomes but slightly plastic on kneading. The natural grasses are bunch grass and alfilerilla; also, a weed commonly called "turpentine-weed" (*Trichostema*). The sample was taken to a depth of twelve inches from the surface, though there was no apparent change for thirty inches.

No. 1190. *Soil* from Sec. 28, T. 12 S., R. 17 E., Fresno County; sent by Mr. John Brown, Madera. This is a gray, sandy soil; the dry lumps are easily crushed between the fingers; becomes but very slightly plastic on kneading, and darkens considerably on wetting. The natural grasses are bunch grass, alfilerilla, and "salt grass." The sample was

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taken to a depth of twelve inches from the surface; at fourteen inches there is a heavy, sandy subsoil.

No. 1191. Soil from Sec. 15, T. 12 S., R. 17 E., Fresno County; sent by Mr. John Brown, Madera. The soil is dark in color, and its dry lumps are hard to crush between the fingers; it becomes quite plastic on wetting, and darkened considerably. It contains some specks of bog ore. It would not be tillable in wet weather. The natural grasses are bunch grass, salt grass, and turpentine-weed. The sample was taken to a depth of twelve inches from the surface; below fifteen inches the subsoil is sandy and light colored.

Soils from Madera, Fresno County.

	No. 1189. Sec. 17, T. 12 S., R. 17 E. Soil.		No. 1190. Sec. 28, T. 12 S., R. 17 E. Soil.		No. 1191. Sec. 15, T. 12 S., R. 17 E. Soil.	
Coarse materials >0.5mm	15.85		7.00		5.00	
Fine earth	84.15		93.00		95.00	
	100.00		100.00		100.00	
Analysis of Fine Earth.						
Insoluble matter	65.79	77.83	73.31	84.04	52.88	71.14
Soluble silica	12.04		10.73		18.26	
Potash (K_2O)	1.32		.67		1.01	
Soda (Na_2O)	.14		.23		.22	
Lime (CaO)	.99		1.31		1.10	
Magnesia (MgO)	1.54		1.74		1.28	
Br. ox. of manganese (Mn_3O_4)	.02		.03		.02	
Peroxide of iron (Fe_2O_3)	6.65		4.09		7.78	
Alumina (Al_2O_3)	7.73		3.97		9.52	
Phosphoric acid (P_2O_5)	.06		.16		.08	
Sulphuric acid (SO_3)	.01		.05		.01	
Water and organic matter	3.62		3.67		7.58	
Totals	99.91		99.96		99.74	
Humus	.88		1.08		2.32	
Ash	.52		.74		1.03	
Sol. phosphoric acid	.02		.03		.02	
Silica	.47		.66		.89	
Hygroscopic moisture (absorbed at 15° C.)	2.73		3.84		7.02	

These fall within the limits of good, thrifty soils, without extreme physical character, and therefore adapted to a great variety of cultures. The most substantial is No. 1191, but from its appearance it seems not to be well drained, and is therefore recommended for figs, apricots, etc., rather than for grapes. No. 1190 ought to be good grain as well as fruit land; while No. 1189, being light in phosphoric acid and high in potash, and rather disposed to be droughty, is best adapted to grapes.

C. COAST RANGE.

No. 1029. Shell soil from Bay Island Farm, Alameda County; sent by John O. Titlow, San Francisco.

"The land seems to be of drift material for from three to five feet deep; then a layer of sand of six inches, underlaid by hardpan."

The soil contains much visible shell debris mixed with dark mold and some sand; in handling it the fingers become blackened. On wetting it hardly shows any adhesiveness, but becomes sooty black.

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Soil of Bay Island Farm, Alameda County.

	No. 1029. Shell Soil.	
Coarse materials >0.5mm (mostly shells)	40.22	
Fine earth	59.78	
	100.00	
Analysis of Fine Earth.		
Insoluble matter	69.94	73.47
Soluble silica	3.53	
Potash (K_2O)	.28	
Soda (Na_2O)	.32	
Lime (CaO)	8.21	
Magnesia (MgO)	.43	
Br. ox. of manganese (Mn_3O_4)	.08	
Peroxide of iron (Fe_2O_3)	1.76	
Alumina (Al_2O_3)	2.66	
Phosphoric acid (P_2O_5)	.70	
Sulphuric acid (SO_3)	.16	
Carbonic acid (CO_2)	5.20	
Water and organic matter	6.51	
Total	99.77	
Humus	4.26	
Ash	.49	
Hygroscopic moisture (absorbed at 15°C.)	5.67	

This soil is naturally very rich in lime, and extraordinarily so in phosphoric acid, exceeding in this respect any soil thus far known to me; it is, of course, derived from the animal matter, fish bones, etc., which have gone into the shell bed. In potash the soil is not rich, but under the circumstances of its formation the amount present is probably very largely available; yet potash will doubtless be the first substance required when fertilization shall be needed. Its content of humus is unusually large.

This land is hardly well adapted to general fruit culture, but should yield high returns in vegetables, grain, or forage plants. Of orchard fruits, plums, figs, and quinces would probably suit the conditions best, and melons will doubtless do finely.

This soil is quite like that of the "shell hammocks" of the Gulf States.

No. 999. Soil from hillside near Wright's Station, Santa Clara County, three and one half miles west of New Almaden quicksilver mines; sent by Mr. C. C. Poppe, Wright's Station. This is a sienna-brown loam; the clods are hard to crush between the fingers; it darkens considerably on wetting, and is somewhat plastic; it is mixed with a good deal of coarse sandy and rocky material. The vegetation is manzanita, small oak, and chaparral bushes. The elevation of the land is about fifteen hundred feet above the level of the sea.

No. 1000. Soil from hillside three and one half miles west of New Almaden quicksilver mines, Santa Clara County; sent by Mr. C. C. Poppe, Wright's Station. The land faces directly north, and is covered with large oak, poison oak, and pepperwood. It is a loose, dark blackish soil, abundantly mingled with angular rock fragments. On wetting it darkens to almost black, and becomes highly plastic; it has but little sand; on handling it easily yields a blackish dust and colors the fingers.

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Soils from Wright's Station, Santa Clara County.

	No. 999. Hillside Soil.		No. 1000. Hillside Soil.
Coarse materials >0.5mm	47.00		
Fine earth	53.00		
	100.00		
Analysis of Fine Earth.			
Insoluble matter	21.53	46.55	
Soluble silica	25.02		
Potash (K_2O)	.31		
Soda (Na_2O)	.26		
Lime (CaO)	1.39		
Magnesia (MgO)	16.97		
Br. ox. of manganese (Mn_3O_4)	.04		
Peroxide of iron (Fe_2O_3)	18.58		
Alumina (Al_2O_3)	4.91		
Phosphoric acid (P_2O_5)	.11		
Sulphuric acid (SO_3)	.02		
Water and organic matter	11.74		
Total	100.88		
Humus	2.75		9.86
Ash	1.40		1.01
Sol. phosphoric acid	.04		.11
Hygroscopic moisture (absorbed at 15° C.)	10.47		10.33

The red soil, No. 999, which is evidently somewhat refractory in tillage, is of very unusual composition, in the extraordinary amounts of magnesia and iron contained in it. The former points to its derivation from some of the serpentinous rocks of the region, which accounts also for its poverty in potash. It has, however, good supplies of lime and phosphoric acid, and an unusually high percentage of humus. The latter condition is exaggerated in the hillside soil, No. 1000, which is manifestly one of the characteristic "redwood soils," noted for their profuse productiveness; although, in such a case as this, better adapted to vegetables than fruit. In the latter direction the red soil is doubtless preferable, and with good cultivation will yield excellent results. The high percentage of readily soluble phosphoric acid promises high and lasting productiveness; but potash manures will probably be necessary before many years under heavy cropping with fruit, especially in the case of grapes. The remarkably high absorption of moisture promises good security against damage from drought or hot winds.

No. 1075. Soil, from cañon in Chile's Valley, Napa County; sent by Mr. F. Sievers, San Francisco. The soil is a yellowish-gray loam, quite light and easily tilled; the subsoil is slightly effervescent with acids, and heavier, yet not refractory. The sample was taken to a depth of twelve inches.

No. 1077. Soil, from the hillside bordering Chile's Valley, Napa County; sent by Mr. F. Sievers, San Francisco. The soil is a yellow or fawn-colored adobe, brown when dry, and barely yields to the finger; it is moderately stiff when wet. It is underlaid at three feet by a very stiff subsoil. The sample was taken at twelve inches depth.

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Soils of Chile's Valley, Napa County.

	No. 1075. Cañon Soil.		No. 1077. Hillside Adobe Soil.	
Coarse materials >0.5mm	4.00		21.00	
Fine earth	96.00		79.00	
	100.00		100.00	
Analysis of Fine Earth.				
Insoluble matter	60.26	74.85	33.89	62.03
Soluble silica	13.59		28.14	
Potash (K_2O)	1.48		.67	
Soda (Na_2O)	.41		.75	
Lime (CaO)	.30		2.49	
Magnesia (MgO)	1.43		10.77	
Br. ox. of manganese (Mn_3O_4)	.05		.19	
Peroxide of iron (Fe_2O_3)	6.97		10 22	
Alumina (Al_2O_3)	10.85		7.38	
Phosphoric acid (P_2O_5)	.08		.08	
Sulphuric acid (SO_3)	.01		.03	
Water and organic matter	4.85		5.84	
Totals	100.28		100.45	
Humus	.59		.82	
Ash	.70		.40	
Sol. phosphoric acid	.03		.02	
Hygroscopic moisture (absorbed at 16½° C.)	6.38		7.22	

These two soils differ widely in composition in most respects, the valley soil being very rich in potash and poor in lime, while the other is strongly calcareous, with but a moderate yet quite adequate supply of potash. The high figure for magnesia indicates the derivation of this soil from some of the "soapstone" or magnesian shales that occur so frequently in the Coast Range. Phosphoric acid is in only moderate supply in both, but in the valley soil much of it is in the soluble form; still, phosphates will here as elsewhere probably be the first fertilizer required when the soils' production slackens. The supply of humus is only fair in the valley soil, and should be supplemented by green-manuring. The character and great depth of the valley soil render it specially adapted to general fruit culture.

No. 880. Tule soil, from inside of the levee on Grizzly Island, Sacramento County; sent by Mr. Warren Dutton, Dutton's Landing. The soil is a grayish silt with very little grit; becomes just a little adhesive when wetted. At the top it is penetrated with the roots of alkali grass. On a freshly-cut surface it is somewhat marbled blue and yellow, with dots of bog ore; it crushes between the fingers.

The soil (No. 881) on the outside of the levee is blackish and more clayey than the above, and its dry clods cannot be readily crushed between the fingers. It contains 6.86 per cent of moisture, air-dried, and 22.26 per cent of organic matter.

The inside soil, whose analysis is given below, consists almost entirely of fine earth.

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Tule Soil, Sacramento County.

	No. 880. Grizzly Island Soil.	
Analysis of Fine Earth.		
Insoluble matter	50.46	65.48
Soluble silica	15.02	
Potash (K_2O)	.65	
Soda (Na_2O)	.44	
Lime (CaO)	.71	
Magnesia (MgO)	1.71	
Br. ox. of manganese (Mn_3O_4)	.07	
Peroxide of iron (Fe_2O_3)	6.92	
Alumina (Al_2O_3)	13.43	
Phosphoric acid (P_2O_5)	.08	
Sulphuric acid (SO_3)	.18	
Water and organic matter	10.16	
Total	99.83	
Humus	1.95	
Ash	.47	
Hygroscopic moisture (absorbed at 15° C.)	10.96	

This soil certainly seems to be worthy of reclamation by drainage, if such has not already been done when its levees were built. There is a large percentage of potash present, with a fair amount of phosphoric acid; while any sourness or acidity that might arise from its large content of organic matter will be neutralized by its lime and magnesia.

No. 1230. Soil of the "sand hills," six miles east of Antioch, and three miles northwest of Brentwood; sent by L. L. Guss, Wrights, Contra Costa County. "The land is nearly level, and is covered with chaparral brush. There are some almond trees in bearing on land of this character, and they yield enormously, but the trees make very little growth; the sand is loose enough to drift when plowed. The sample was taken to the depth of fourteen inches."

Sand Hills Soil, Contra Costa County.

	No. 1230. Sand Hills Soil.	
Coarse materials >0.5mm	5.00	
Fine earth	95.00	
	100.00	
Analysis of Fine Earth.		
Insoluble matter	88.07	92.04
Soluble silica	3.97	
Potash (K_2O)	.24	
Soda (Na_2O)	.09	
Lime (CaO)	.66	
Magnesia (MgO)	.34	
Br. ox. of manganese (Mn_3O_4)	.02	
Peroxide of iron (Fe_2O_3)	3.41	
Alumina (Al_2O_3)	1.89	
Phosphoric acid (P_2O_5)	.06	
Sulphuric acid (SO_3)	.02	
Water and organic matter	1.28	
Total	100.05	
Humus	.33	
Ash	.46	
Sol. phosphoric acid	.02	
Silica	.13	
Hygroscopic moisture (absorbed at 15° C.)	3.94	

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In view of the extreme sandiness of the soil (92.04 of sand, etc.), it is very well supplied with plant-food, and if of sufficient depth, should prove very productive of fruit, at least, and anything else that has deep roots. It would not last long for grain; peaches and almonds, and grapes for wine, would be its special adaptation if the climate permits; but the depth of the soil above bedrock should not be less than eight or ten feet.

No. 1178. Tule soil, from marsh meadows at the mouth of Eel River, Humboldt County; sent by G. H. Kellogg, of San Francisco. This is a light gray soil, of a silty character, much netted with tule roots, whose course is marked by rusty streaks, while rust spots also appear here and there. The dry lumps crush with difficulty between the fingers; they soften quickly and darken in color on wetting, and become slightly plastic on kneading. No coarse sand or gravel is present.

Tule Soil, Humboldt County.

	No. 1178. Mouth of Eel River Soil.	
Coarse materials >0.5mm	5.00	
Fine earth	95.00	
	100.00	
Analysis of Fine Earth.		
Insoluble matter	51.33	58.49
Soluble silica	7.16	
Potash (K_2O)	.34	
Soda (Na_2O)	.32	
Lime (CaO)	2.06	
Magnesia (MgO)	4.39	
Br. ox. of manganese (Mn_3O_4)	.05	
Peroxide of iron (Fe_2O_3)	9.56	
Alumina (Al_2O_3)	6.04	
Phosphoric acid (P_2O_5)	.13	
Sulphuric acid (SO_3)	.38	
Water and organic matter	17.98	
Total	99.74	
Humus	1.71	
Ash	.17	
Sol. phosphoric acid	.04	
Hygroscopic moisture (absorbed at 15° C.)	11.64	

Common salt, .083 per cent, was obtained by leaching the soil.

This soil is evidently not greatly subject to tidal overflow, as it contains so little of the sea salt that otherwise would form an obstacle to its cultivation. In its chemical composition it shows good proportions of lime, phosphoric acid, and humus; but no very large amount of potash, albeit the latter would not be found deficient for some time. The land will, doubtless, if properly drained, yield full crops of grain or hay for a number of years, and for the present would not seem to require any liming, as is so commonly necessary in marshes elsewhere.

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D. SOUTH CALIFORNIA.

SOILS OF THE SOUTH CALIFORNIA STATION.

The establishment of a culture sub-station for South California, on land situated not far from Pomona, but within the limits of the Chino Ranch, was announced in the "Report to the President of the University" for 1890. Considerable progress has been made in the equipment and planting of this station, although the funds available for the purpose were materially below what could have been desired; since it was necessary to maintain the three stations already established, and to start and equip the fourth, within the limits of the sum which will barely suffice to "run" all four when once fully equipped. Some data regarding the progress made will be found in the report of the Inspector, Mr. Shinn, in another portion of this report. It is intended, so soon as the equipment and occupation of the South California Station shall be completed, to render a report on it and on the region it is intended to represent, as far as possible on the same plan pursued in a former publication treating of the other stations; including, therefore, as full a description of the physical and agricultural features of South California as the data at command will permit. As this report cannot be written until some time in 1892, some of the work done in that section since the last general report was published, will be reported upon in the present publication, for the more prompt information of the population interested.

The South California Station tract comprises two plots of land, situated about two miles apart, both donated by Mr. Richard Gird, from land of the Chino Ranch. The main tract of thirty acres is on the northern line of that ranch, about two miles from Pomona and two and one half miles from Chino town. On it are located the station house and other improvements, the expense of the buildings having been provided for by subscription among the citizens of Pomona; while the water supply, at the rate of one inch for each ten acres, was also donated by Mr. Gird. The soils of this tract comprise about five sixths of "red mesa" land, such as has proved specially appropriate for the culture of citrus fruits; while the rest represents the gray, gravelly soil that characterizes the "washes" from the Sierra Madre. It is on this tract, of course, that the main plantation of fruit trees has been made. Water is found in this land at from forty-five to sixty feet depth, in gravel.

The other tract, of ten acres, lies about two miles to southward of the first, and forms part of the wide belt of "moist lands" which border Chino Creek and require no irrigation, and are considered as more specially adapted to field crops. Water is here found at twelve to fifteen feet. This tract is within half a mile of the Chino townsite and about four miles from the town of Pomona.

The soils examined represent the main body of the land of both tracts, so far as single specimens can do so; a more detailed examination will be made hereafter.

No. 1281. Surface soil, taken near the center of the main tract of the station, to twelve inches depth. It is a reddish gray or fawn-colored, sandy loam; the dry lumps fall to pieces readily, and show much sand, some coarse, up to one eighth inch diameter. The sand grains are mostly granular, colorless quartz, with much feldspar, black grains of augite, as well as of hornblende and some garnet, occasionally

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mbedded in fragments of chlorite schist. These minerals prove the derivation of the soil from the head of the San Bernardino Valley, as against the gravelly "wash" soil, which contains only the granitic minerals of the Sierra Madre, where it is drained by San Antonio Creek. The soil when wetted darkens slightly and becomes slightly plastic, but not adhesive. The vegetation on this land is predominantly the sunflower, of small size because of dryness, a little blue sage, short grass, spinous-leaved gilias (*G. filifolia, attractiloides*), and turkey-weed (*Eremocarpus setigerus*).

No. 1282. Subsoil, taken from twelve to twenty-four inches depth; it is quite similar to the soil, but a little more clayey and compact.

No. 1284. "Adobe" soil from the moist lands bordering Chino Creek; taken to twelve inches depth. A mouse-colored, moderately clayey loam, somewhat silty; the dry lumps crush quite readily between the fingers, and show little or no grit. With acid there is effervescence; on wetting, the color deepens considerably, and when kneaded the soil becomes quite adhesive, showing that it must not be tilled while wet. Its natural vegetation is a dense, tall growth of grass, with some spots bearing the "Yerba mansa" (*Anemopsis Californica*) and sunflower.

Soils from South California Station.

	Center of Main Tract—Mesa or "Dry Land."		South Plot—"Moist Land."
	No. 1281. Soil.	No. 1282. Subsoil.	No. 1284. Soil.
Coarse materials >0.5mm	10.00	11.00	1.00
Fine earth	90.00	89.00	99.00
	100.00	100.00	100.00
Analysis of Fine Earth.			
Insoluble matter	67.98	70.46	62.62
Soluble silica	9.51 } 77.49	7.26 } 77.72	8.30 } 70.92
Potash (K_2O)	.93	.90	.95
Soda (Na_2O)	.42	.33	.50
Lime (CaO)	1.75	2.26	5.07
Magnesia (MgO)	.82	1.91	.84
Br. ox. of manganese (Mn_3O_4)	.05	.04	.06
Peroxide of iron (Fe_2O_3)	7.07	7.85	6.43
Alumina (Al_2O_3)	7.72	5.72	4.88
Phosphoric acid (P_2O_5)	.20	.13	.21
Sulphuric acid (SO_3)	.03	.06	.06
Carbonic acid (CO_2)			3.76
Water and organic matter	3.49	2.82	6.02
Totals	99.97	99.74	99.70
Humus	.58		1.99
Ash	.26		1.13
Sol. phosphoric acid	.02		.03
Silica	.20		.96
Hygroscopic moisture (absorbed at 15° C.)	1.98	2.22	5.81

The showing made by these analyses places these two soils high in the scale of productiveness, with large proportions of potash, lime, and phosphoric acid; and it is a curious fact that the lowland or moist soil differs from the mesa soil in only one material point so far as the mineral ingredients are concerned, namely, the lime percentage. Supposing the two to be derived from the same original material, this accumulation of lime in the lowland soil is to be expected on general grounds. The same

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is of course true as regards the humus, which, with the greater moisture and more luxuriant growth borne by the soil that is naturally moist throughout the season, must also be expected.

It is important to compare these soils with those of other parts of the southern region, which are supposed to be reasonably well represented on the station plots. A reference to the analyses given farther on, of four soils and subsoils from Riverside, and of six from the Temescal Valley, near South Riverside, shows a very near correspondence, in all important points, in the mesa materials proper.

RIVERSIDE SOILS.

The soils occurring within the limits of the Riverside basin are substantially of two chief types, the intermixture of which produces the best soils for citrus culture, and occupy the largest areas. Pure granite soils, of a very light type, occupy the slopes and immediate base of the granitic ridges of the region, and may be seen characteristically at the west end of Roubidoux Mountain and elsewhere. On the other hand, more or less heavy orange-tinted loams form a practically continuous belt, or upper terrace, along and around the whole of the San Bernardino Valley; they appear in force from Redlands southward, especially in the San Timoteo Cañon, through which the Southern Pacific Railroad passes, up to the Gorgonio Pass; and much of this loamy ingredient in the soils of Riverside is directly traceable to that cañon, from which a conspicuous red terrace extends to and around the Riverside basin. Its continuation is there known as "Arlington Heights," the name applying specially to that portion lying above the old Riverside ditch, and now covered by the Gage Canal. The soil of the Heights is a mixture of granitic sand with the red loam of the terrace formation proper. Ridges of this red soil extend down into the older portion of the colony, but the greater portion of the lands under the Riverside ditch is of a gray tint, and ranges in texture from a light loam to what is popularly designated as adobe, although rarely so heavy as to deserve that designation in the sense in which it is mostly used outside of South California. It is not at all outside of the limits of the loams that are a postulate for citrus culture. In the lowest ground—the trough of Tequisquite arroyo—there lies quite a light, sandy soil, brought down by the overflows.

Nearly everywhere these soils are of great depth; in the breaks on the Arlington tract, profiles of as much as thirty feet of sensibly uniform red loam may be seen, and it will be noted by reference to the table below that it is of almost uniform composition, chemically, to the depth of ten feet at least. The roots of the wild shrubs are found within it to depths of from six to eight feet, showing it to be as easily penetrable to roots as it is to water; its red tint alone being proof of its perfect drainage.

The sand contained in these soils is simply pulverized and partially decomposed granite, which by its further decomposition, accelerated by cultivation, will continue to evolve available plant-food for many years to come. The original natural vegetation is vigorous, and consists largely of the white and blue sages, the shrubby sunflower, cactus, "chaparral," some clumps of greasewood, and bushes of the elder, substantially the same as on the lower ground, now mostly occupied by the orange orchards of Riverside. A good portion of these are located on precisely the same red soil, whose producing quality is therefore estab-

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lished by actual experience, being practically the same as that of the lands first occupied because of their lower level and easier irrigation from the original sources of water supply.

In the table below are given the analyses of five representative soils from the Riverside region, and one (No. 1537) which is quite exceptional, and confined to particular ridges.

Nos. 809 and 812 are representative samples of the soils of the older colony lands lying under the old Riverside ditch. They were taken by Mr. G. L. Waring, of Riverside. Nos. 1406 and 1408 are from a locality about two hundred feet higher, and represent the higher lands of "Arlington Heights," lying under and irrigated from the Gage Canal. No. 1536 is from the lower ground under the Gage Canal, about four miles southeast from the town of Riverside.

Nos. 809 and 812. Light and heavy subsoils from Riverside. "When dry the soil is grayish; when wet, a light chocolate color, rather hard and gritty in character; and when flooded, and not subsequently broken up, it bakes very hard. The stiffer land is rather hard to work and unfriable, but where more sand is present it can be broken up into very small particles."—G. L. Waring.*

No. 1406. Reddish-brown sandy loam soil, with much mica and some granitic debris; from the break near the head of Flume No. 11 of the Gage Canal, Arlington Heights, Riverside; taken to a depth of twelve inches. It becomes slightly plastic on kneading with water. The vegetation is cactus, Baeria, Croton, and greasewood.

No. 1408. Under-subsoil of the above; very similar to it in color and appearance, somewhat lighter, with much mica and granitic debris; taken at a depth of from nine to ten feet.

No. 1536. Brownish loam soil, from Arlington Heights, lot 1, block 37, Windsor tract, Riverside Orange Company. Contains little mica and much coarse granitic debris; it softens when wetted, and becomes fairly plastic on kneading. Taken to a depth of twelve inches.

No. 1537. Stiff reddish-brown clay soil, spotted with whitish granitic debris, mostly feldspar, quite coarse; from the Balmoral tract, Riverside Orange Company, lower end of the Gage Canal, lot 2, block 8, of the Gage survey, Riverside. It softens slowly when wetted, and on kneading becomes extremely tenacious.

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* Report College of Agriculture for 1886, page 32.

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Soils of Riverside, San Bernardino County.

	Old Riverside Colony.		Near North End of Trestle 11, Gage Canal, Arlington Heights.		Riverside Orange Company.	
	No. 809. Lighter Subsoil.	No. 812. Heavier Subsoil.	No. 1406. Reddish Sandy Loam Soil.	No. 1408. Sandy Loam Under-Subsoil.	No. 1536. Windsor Tract, Mesa Loam Soil.	No. 1537. Balmoral Tract, Red Ridge Adobe Soil.
Coarse materials >0.5mm	37.60	26.60	20.00	23.00	25.00	38.00
Fine earth	62.40	73.40	80.00	77.00	75.00	62.00
	100.00	100.00	100.00	100.00	100.00	100.00
Analysis of Fine Earth.						
Insoluble matter	78.36	68.34	76.41	75.44	63.67	58.94
Soluble silica	5.62 } 83.98	7.10 } 75.44	8.20 } 84.61	8.07 } 83.51	13.70 } 77.37	14.49 } 73.43
Potash (K_2O)	.79	.97	.87	.93	.73	.69
Soda (Na_2O)	.56	.31	.29	.36	.36	.34
Lime (CaO)	1.51	1.65	1.57	1.73	1.58	1.71
Magnesia (MgO)	1.24	1.68	1.33	1.58	1.85	1.78
Br. ox. of manganese (Mn_3O_4)	.28	.04	.04	.04	.03	.03
Peroxide of iron (Fe_2O_3)	3.70	3.64	4.20	5.34	10.02	6.56
Alumina (Al_2O_3)	6.68	10.19	5.30	5.08	5.06	11.77
Phosphoric acid (P_2O_5)	.11	.05	.14	.16	.07	.03
Sulphuric acid (SO_3)	.05	.04	------	------	.01	.01
Water and organic matter	1.66	2.41	1.60	1.44	2.74	3.87
Totals	100.46	99.96	99.85	100.17	99.82	100.22
Humus	.12	.19	.20	------	.20	.06
Ash	.31	.39	.64	------	.35	.18
Sol. phosphoric acid	------	------	.02	------	.04	.02
Silica	------	------	.26	------	.28	.10
Hygroscopic moisture	2.60	5.50	1.77	2.16	4.71	10.80
Absorbed at	14° C.	14° C.	15° C.	15° C.	13° C.	13° C.

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It will be seen that in almost all respects these soils are much alike, having large supplies of potash and lime, of which substances the variations are within narrow limits. As regards phosphoric acid, it is a curious and unexpected fact that while the soils from the higher ground are well supplied with it, the heavier soils from the lower grounds—Nos. 812 and 1536—have a relatively low supply, which, in the case of the former, approaches deficiency. The explanation of this departure from the usual rule is found in the composition of the heavy red clay soil, No. 1537, which, while similar to the lighter soils in respect to the other ingredients of plant-food, is exceptionally poor in phosphoric acid, and has by its admixture (washing down from the granitic ridges) doubtless depressed the contents of the heavier soils in this respect. This "red adobe" seems to be formed directly from the granite of the ridges; and it is an important practical conclusion that wherever this heavy red soil prevails, fertilization with phosphates is preëminently called for. It is, however, ill adapted to citrus fruits at best.

But all—even the heavier soil from the lower ground—are quite deficient in humus, and correspondingly in nitrogen; so that the supplementing of the latter substance (*e. g.*, by dressings of Chile saltpeter) is indicated as the first step in fertilization, notably of orange orchards, which draw heavily on nitrogen when in bearing. Experience has already fully justified this induction, the good effects of nitrogenous fertilizers having been verified in numerous cases.

The low moisture-absorption of the light loam soils, Nos. 809 and 1406, speaks of the need of deep tillage and frequent irrigation for so exacting a tree as the orange. The more retentive soils, if well tilled, will not dry out so quickly.

SOILS OF THE TEMESCAL VALLEY.

From a special examination of the lands and water resources of the South Riverside Land and Water Company, the following points of general interest are given by consent of the company:

The colony sites of South Riverside and Auburndale cover the greater part of the lower valley of Temescal Creek; the latter, lying to northward of the stream, is a gently rolling mesa land, bounded on the southwest by the wash of Temescal Creek, to which there is an abrupt descent, or bluff. On the opposite side of that stream the land rises on a gentle slope to the base of the Santa Ana Mountains, from a minimum elevation of about five hundred to as much as one thousand four hundred feet, forming a plateau slope from two to three miles wide, on the upper portion of which is the townsite of South Riverside. The soil on both sides is prevalently of the reddish-loam character. On the right (Auburndale) side this loam is usually free from gravel, and sometimes quite sandy; on the South Riverside slope it is almost throughout much mixed with gravel. There is, generally, little change in the character of these soil-materials for depths ranging from five to ten feet; in wells a much greater thickness has been observed. These mesa soils become somewhat heavier as the Santa Ana foothills are approached, because of the red clayey material that forms the base of the slopes, locally passing into veritable adobe. Sometimes they are heavily packed with gravel, mostly of light-colored granite, with more or less of black siliceous schist. On the lower slope, near the South Riverside townsite,

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and reaching higher up as the Santa Ana River is approached (near Rincon), there lies a gray, and usually very gravelly soil, the gravel being chiefly a dark-colored siliceous schist, derived from the upper cañons of the valley. This land is quite distinct from the reddish mesa soil, and may be considered the "wash" of the Temescal Valley at a time when the water was of much greater volume than at present.

The natural vegetation of these mesas is that of the dry mesas of South California generally—some cactus, white sage, sagebrush, and herbaceous plants of similar import; at many points the bunch grass (*Festuca*) forms a conspicuous and welcome ingredient of the vegetation. The shallow washes, or coulèes, that in time of heavy rains carry off the surplus water of the cañons, are marked by a vigorous growth of two species of sumac, the California buckthorn, some chaparral (*Ceanothus*), greasewood, and scattered elder bushes. The adjacent slopes of the Santa Ana Range are kept green all the year by a short growth of chaparral, toyon (*Heteromeles*), buckthorn, and scrub oaks, in pleasant contrast to the bare, rocky sides of the Sierra Madre and Temescal Ranges opposite.

The following table shows the result of the analysis of a number of soils taken at various points so as to cover essentially the two colony tracts. All except Nos. 1249 and 1245 represent the soil layer from the surface to the depth of twelve inches.

No. 1248. *Soil* from the foot of the slope (lot 7, block 67), South Riverside, typical of the valley "wash" referred to above. Gray, very gravelly; natural vegetation originally cactus patches, with turkey-weed, sunflower, tar-weed, and elder bushes. Quite plastic when kneaded, does not darken much in wetting; gravel all well rounded; much black siliceous schist.

No. 1246. *Mesa soil* from an orange orchard on lot 6, block 43, nearly on the division line between the gray soil of the lower lands and the reddish mesa soil; dark colored, with but little gravel; a rich-looking blackish loam, becoming quite plastic on wetting, and darkening considerably in color. Original vegetation, turkey-weed, tar-weed, sunflower, and elder bushes.

No. 1251. *Mesa soil*, twelve inches deep, from tract on the line of the pipe-line, lot 2, block 31, representing about the middle of the mesa slope, near the eastern line of the company's lands. A reddish, gravelly loam, darkening considerably on wetting, and becoming quite plastic. Original vegetation about the same as the preceding number. The gravel is largely angular, and mostly granitic.

No. 1253. *High mesa soil*, twelve inches deep, from the high mesa (one thousand three hundred feet), half a mile from the foothill slope, lot 6, block 3, near the line of the Garretson tract; represents fairly the mesa within a mile or a mile and a half of the foothills of the Santa Ana Range. Quite reddish, with much angular gravel, mainly granitic; becomes very plastic on wetting, and darkens materially in color. Vegetation: bunch grass, alfilerilla, turkey-weed, and tar-weed.

No. 1249. *Subsoil* from the bottom of the ditch, six feet below the surface, at the crossing of Ontario and Buena Vista Avenues. Very gravelly, reddish-gray loam, less clayey than the surface at the same point.

Nos. 1244 and 1245. *Soil and subsoil* from the Auburndale tract, lot 1, block 90. A fair average of the tract at large; the subsoil, at a depth

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of twelve to thirty inches, being chosen for examination on account of the great depth of the unchanged soil stratum, which in breaks is shown to be uniform for six to eight feet. Natural vegetation: patches of cactus, much bunch grass, turkey-weed, alfilerilla. The soil contains much coarse white sand, and becomes only slightly plastic on wetting, while darkening but little in color.

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Analyses of Soils from the South Riverside and Auburndale Colony Lands.

	No. 1248. "Temescal Wash," Block 67, Lot 7. Soil.		No. 1251. Block 31, Lot 2, East-end, near Pipe-line. Mesa Soil.		No. 1246. Block 43, Lot 6, near Townsite. Mesa Soil.		No. 1253. Block 3, Lot 6, near Garretson's. High Mesa Soil.		No. 1249. Pipe-line Ditch, Ontario Ave. Mesa Subsoil.		No. 1245. Block 90, Lot 1, Auburndale. Mesa Subsoil.		No. 1244. Block 90, Lot 1, Auburndale. Mesa Soil.
Coarse materials >0.5mm	20.00		17.00		27.50		57.00		80.00		30.00		
Fine earth	80.00		83.00		72.50		43.00		20.00		70.00		
Analysis of Fine Earth.													
Insoluble matter	67.38	78.07	71.89	80.32	58.19	72.72	69.86	78.55	73.57	80.01	73.44	83.50	
Soluble silica	10.69		8.43		14.53		8.69		6.44		10.06		
Potash (K_2O)	.74		1.17		.68		1.17		1.35		.77		
Soda (Na_2O)	.11		.13		.24		.33		.25		.19		
Lime (CaO)	1.11		1.19		1.15		.96		.57		1.10		
Magnesia (MgO)	1.40		1.29		1.30		1.27		.87		1.01		
Br. ox. of manganese (Mn_3O_4)	.14		.04		.05		.04		.05		.04		
Peroxide of iron (Fe_2O_3)	7.79		5.39		9.29		5.79		4.93		5.17		
Alumina (Al_2O_3)	6.32		7.04		8.29		8.15		8.72		5.84		
Phosphoric acid (P_2O_5)	.09		.11		.12		.11		.07		.10		
Sulphuric acid (SO_3)	.02		.01		.07		.04		.04		.02		
Water and organic matter	3.79		3.47		6.09		3.90		2.91		2.39		
Totals	99.58		100.15		99.96		100.31		99.77		100.13		
Humus	.69		.64		1.09		.84						.49
Ash	.73		.54		.59		.77						.53
Sol. phosphoric acid	.03		.04		.04		.04						.03
Silica	.61		.35		.37		.29						.34
Hygroscopic moisture (absorbed at 15° C.)	7.84		3.00		6.89		3.10		4.43		4.50		

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The salient point in the composition of all these soils is their high content of *potash*, exceeding 1 per cent in three cases in the South Riverside tract. This, with the large proportion of the same substance contained in the irrigation water, noticed elsewhere, guarantees the cultivator against the need of supplying this ingredient for a long time.

Lime, also, is in ample supply in all the soils, including the "wash" soil of the lower land. A somewhat unusual feature is, that the subsoil at six feet (No. 1249) contains only half as much as the surface soils, owing probably to its more sandy nature.

Phosphoric acid, likewise, is in good supply in all, and will not require artificial supplementing for a number of years, since an unusually large proportion is in the soluble condition.

The supply of *humus*, or vegetable matter (and with it that important substance, nitrogen), is unexpectedly large for mesa soils, especially in No. 1246, which contains about three times as much as is commonly found in such soils. In the rest it is at least adequate.

As regards *physical properties*, it will be noted that Nos. 1253 and 1249 are quite gravelly; none are close; all are easily tilled. Nos. 1248 and 1246 possess a much higher power of absorbing moisture than the rest, and will, therefore, be less sensitive to heat and drought. The rest are in this respect more nearly like the generality of mesa soils in Southern California.

As a general result, it may be said that these soils are of very high quality, and, in view of their physical character, depth, and good drainage, may be considered as especially well adapted to the culture of citrus, as well as most deciduous fruits, and also to the olive; considering the climate, the almond seems to be particularly indicated as a promising crop.

Soil-Forming Materials from Near Santa Monica.—The materials, of which the analyses are given below, were analyzed at the request and expense of the Forestry station, near Santa Monica. It is stated that they constitute the two chief varieties of material from which the hillside soils of that region are formed; hence, it was desired to know their probable permanent value as supporters of forest growth.*

No. 1521. Gray silty clay, from hillside near Forestry station, Santa Monica, Los Angeles County; sent by Mr. William S. Lyon, State Board of Forestry, Los Angeles. This is an indurated soil-forming material; only slightly plastic with water; the lumps are rather easily crushed between the fingers.

No. 1522. Yellow ochreous earth, from hillside near Forestry station; sent by Mr. William S. Lyon. This material is quite indurated, but crushes rather easily between the fingers, and becomes quite plastic with water. Its iron is in the form of fine grains of limonite or yellow ochre.

*See Bulletin No. 6 of the California State Board of Forestry, page 5.

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Analyses of Soil-Forming Materials, Santa Monica, Los Angeles County.

	No. 1521. Gray Silty Clay.		No. 1522. Yellow Ochreous Earth.	
Insoluble matter	49.95	70.68	48.57	56.82
Soluble silica	20.73		8.25	
Potash (K_2O)	1.09		1.54	
Soda (Na_2O)	.66		.85	
Lime (CaO)	3.23		8.14	
Magnesia (MgO)	2.86		2.45	
Br. ox. of manganese (Mn_3O_4)	.05		.02	
Peroxide of iron (Fe_2O_3)	8.11		18.19	
Alumina (Al_2O_3)	6.77		1.51	
Phosphoric acid (P_2O_5)	.23		.28	
Sulphuric acid (SO_3)	2.65		.73	
Carbonic acid (CO_2)	.....		3.18	
Water	3.60		6.38	
Totals	99.98		100.09	
Hygroscopic moisture (absorbed at 15° C.)	10.87		.....	

The gray clay, on leaching, yielded 4.40 per cent of soluble salts, mostly gypsum.
The yellowish earth yielded, on leaching, 3.18 per cent of soluble salts, which consisted chiefly of common salt, very little gypsum, and some sulphates of soda and potash.

Both of these materials are rich in the essential mineral ingredients of plant-food; No. 1522 particularly so, since it contains over one and a half per cent of potash, and nearly three tenths of one per cent of phosphoric acid; the latter an extraordinarily high amount for this State. Both are strongly calcareous, the yellow variety especially so, and both have a very high power of absorbing moisture. Both contain some "alkali," but of the mild ("white") form, as must be the case in the presence of a considerable proportion of *gypsum* in both. Apart from the alkali, which may have been present accidentally in samples taken from the surface, in larger proportion than would be the case in soils formed from these materials, such soils would be exceedingly productive, if adequately supplied with vegetable matter, or, in its absence, with nitrogenous fertilizers.

It will be interesting to ascertain what is the extent of the area of occurrence of soils so unusually rich in phosphates, and to determine whether or not the latter exist in a more concentrated form, available for use as fertilizers; such deposits having lately been actually discovered in the neighborhood of South Riverside.

No. 1238. Bottom soil of Sweetwater Valley, San Diego County; sent by Mr. Wallace D. Dickinson, of San Diego, for the purpose of ascertaining if the land is suitable for potatoes. He says:

Two or three Italians in the Otay Valley have each year planted potatoes in August, irrigating the same with windmills. Last season I determined to experiment with some valley land of my own, lying in the valley of the Sweetwater, and irrigable from the Sweetwater Reservoir. So in June I plowed the land (then very dry), and, making ditches through it, thoroughly soaked the soil; then I ran a cultivator through it, and furrowed it out accurately two and one half feet apart; dropped the seed (good looking and very mature from the fall crop) four inches deep, and covered it by running a "Junior" cultivator between the rows, with the plow wings properly set; this worked quickly and nicely. Two and a half acres were thus planted. I was badly disappointed to find that but few hills came up, and I spent a half day among the Italians trying to locate the trouble. They agreed that the seed was too old, and that potatoes should be planted whole when irrigated. So I replanted the plot with very good, small seed potatoes, some of which were beginning to sprout. The immature seed failed to show any sprouts; from the rest I gathered a crop about November first, realizing about eighty-five sacks per acre.

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In the meantime, however, I had planted another plot on September twentieth, which met with a fate that I would like to have explained. In October, when the plants were about eight inches high, a frost killed about 5 per cent of them, while the balance recovered and were very promising, with a strong, healthy growth, and just beginning to blossom. As I expected rain, I postponed irrigating them until they were pretty dry, though a Chinese gardener claimed they were plenty wet—"heap water no good for potatoes." But as they had not had water for four weeks, I commenced to irrigate, but was interrupted by a heavy rain. Within one week at least one third of the tops were dead, and in two weeks not a green top remained; the potatoes were the size of walnuts, and rotted in the ground at once. Why? Is the soil (a sample of which is sent) suitable for potatoes, or does it require fertilization? I irrigated the plants by allowing the water to flow along center ditches between the rows.

The examination resulted as follows:

Bottom Land of Sweetwater Valley, San Diego County.

	No. 1238. Soil.
Insoluble matter Iron, alumina, etc.	95.45
Potash (K_2O)	.64
Soda (Na_2O)	.22
Lime (CaO)	1.06
Phosphoric acid (P_2O_5)	.06
Water and organic matter	2.57
Total	100.00

For a sandy soil the plant-food percentages are quite large, and even as to humus, which is a common deficiency in the soils of the southern region, the sample is well supplied. The difficulties met with in the above cultivation of the potato are probably purely climatic, or due to the constant high temperature during the late growing season proposed for the crop.

While it is true that the potato is a native of Arizona and northern Mexico, yet in its native habitat it occupies mountain locations, and its tubers are very small. It has been called the "Irish potato" from its peculiar adaptation to a climate about as different from that of Sweetwater Valley as can well be, and it is credited with producing there the maximum of tubers of the best quality.

When the cut potatoes were planted in a hot soil (in July), where they got warm and began to dry on the outside before the water was put on, then chilled down with that water after they had gotten pretty well set with "microbes" in a highly "septic" soil, it was quite natural that the microbes and not the potato germs grew.

Experienced irrigators are agreed that all violent changes caused by the application of water to the roots are dangerous; hence, when it becomes necessary to irrigate during the hot weather the water is not run very close to trees, nor very abundantly at a time, and thus the change is made more gradual.

No. 1092. Soil from Palm Valley, San Diego County; sent by Mr. S. W. Fergusson, San Francisco. This is a grayish, light, loose soil, with small particles of mica, both gray and golden, and of quartz. The Palm Valley Colony is situated on the eastern slope of the San Jacinto Range, off Seven Palms Station, on the Southern Pacific Railroad.

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Soil of Palm Valley, San Diego County.

	No. 1092. Light Gray Soil.	
Coarse materials >0.5mm	None.	
Fine earth	All.	
Analysis of Fine Earth.		
Insoluble matter	71.45	76.95
Soluble silica	5.50	
Potash (K_2O)	1.42	
Soda (Na_2O)	.18	
Lime (CaO)	2.20	
Magnesia (MgO)	2.09	
Br. ox. of manganese (Mn_3O_4)	.05	
Peroxide of iron (Fe_2O_3)	6.08	
Alumina (Al_2O_3)	5.78	
Phosphoric acid (P_2O_5)	.35	
Sulphuric acid (SO_3)	.01	
Carbonic acid (CO_2)	.18	
Water and organic matter	4.29	
Total	100.18	
Humus	1.07	
Ash	.23	
Sol. phosphoric acid	.03	
Hygroscopic moisture (absorbed at 13° C.)	2.06	

There is also .16 per cent "soluble alkali" in this soil, which consists of sulphate of soda (Glauber's salt), sulphate of potash, and a little common salt, not enough to be hurtful.

The analysis of the sample indicates a very rich soil, in which the percentages of plant-food (potash and phosphoric acid) are *very high;* lime and humus in good proportions. Should other conditions, as depth, drainage, and climate, be also favorable, this should be an extremely fertile and thrifty land. In texture it is a light loam, easily tilled.

Soils from the Bottom Lands of the Colorado and Gila Rivers.—An analysis of a sample of soil from the Colorado bottom land, near Yuma, was given in a former report (see page 39, report for 1882). This analysis is reproduced below for comparison with those of a soil and under-subsoil from the Gila River bottom, near the junction of that stream with the Colorado. These samples were sent, with request for analysis, by Mr. Hiram Blaisdell, of Yuma, and the result is here given by his permission.

The three samples are very much alike—of a pale fawn color when dry; fine-textured, silty, with no coarse sand or gravel of any kind. The subsoil, No. 1197, is hardly to be distinguished from the surface soil. They lie loosely, and can be compressed considerably with little exertion. Their natural vegetation is mainly mesquite and "Colorado Hemp."

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Colorado and Gila Bottom Soils.

	No. 506. Colorado River, California. Bottom Soil.		No. 1195. Gila River, Arizona. Bottom Soil.		No. 1197. Gila River, Arizona. Bottom Subsoil.	
Insoluble matter	58.57	63.90	57.90	71.39	64.83	76.68
Soluble silica	5.33		13.49		11.85	
Potash (K_2O)	1.18		.66		.67	
Soda (Na_2O)	.16		.25		.39	
Lime (CaO)	8.67		6.26		4.33	
Magnesia (MgO)	2.97		.66		1.97	
Br. ox. of manganese (Mn_3O_4)	.03		.08		.03	
Peroxide of iron (Fe_2O_3)	4.14		5.57		6.27	
Alumina (Al_2O_3)	8.38		7.48		4.27	
Phosphoric acid (P_2O_5)	.13		.23		.17	
Sulphuric acid (SO_3)	.15		.03		.05	
Carbonic acid (CO_2)	7.82		2.63		3.56	
Water and organic matter	3.34		4.98		1.44	
Totals	100.87		100.22		99.83	
Humus	.75		.38		----	
Ash	1.15		.43		----	
Sol. phosphoric acid	----		.02		----	
Hygroscopic moisture (absorbed at 15° C.)	9.26		4.91		3.48	

It will be noted, as a common feature of these three soils, that they are highly calcareous; they show the presence of carbonate of lime by effervescence with acids. The Colorado soil is very rich in potash; the Gila soil much less so, yet very adequately supplied; the amount of soda found does not indicate much alkali contamination. The Colorado soil has a good but not high supply of phosphoric acid; the Gila soils both show an unusually high percentage of that ingredient. The Colorado soil has a good supply of humus; the Gila soil is notably deficient therein for a bottom soil. The latter point is explained by the fact, collaterally ascertained, that at low stages of water the Gila River carries enough alkali (carbonate of soda) to exert a sensible solvent action upon the humus of the soil.

Although none of these materials become properly plastic on wetting and kneading, it will be noted that the Colorado soil shows a very high moisture-absorption, and a high percentage of alumina. In what form the latter is present, and what determines the high moisture-coefficient in this case, remains to be determined. In the Gila soil the moisture-absorption is, at least, fair.

Taken altogether, these soils should be highly and lastingly productive, and easily tilled if exempt or protected from overflow, and should be adapted to a great variety of crops, determined more by the moisture conditions than by any other factor.

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Number	Soil Title.	Locality.
		FOOTHILLS.
1291	Manzanita soil	Experiment Station, McKay tract
1294	Pine soil	Experiment Station, McKay tract
1115	Granite soil*	Experiment Station, north slope
1113	Slate soil*	Experiment Station, south slope
1139	Red soil	Sec. 7, T. 17 N., R. 14 E., near Moore's Station
1027	Red soil	Eight miles west of Anderson
1028	Red subsoil	Eight miles west of Anderson
1179	White silty soil	East side of Honey Lake
		GREAT VALLEY.
1192	Sandy loam soil	Buhach Colony, Merced
1194	Under-subsoil	Buhach Colony, Merced
1061	Soil	Viticultural experiment plot, E. B. Rogers' place
1063	Subsoil	Viticultural experiment plot, E. B. Rogers' place
1065	Subsoil	Viticultural experiment plot, Dr. Eschleman's pl
1066	Under-subsoil	Viticultural experiment plot, Dr. Eschleman's pla
1055	Fresno Plains red soil	Fruitvale tract, Sec. 9, T. 14, R. 19 E.
1189	Gray silty soil	Sec. 17, T. 12 S., R. 17 E.
1190	Gray sandy soil	Sec. 28, T. 12 S., R. 17 E.
1191	Soil	Sec. 15, T. 12 S., R. 17 E.
		COAST RANGE.
1029	Shell soil	Bay Island Farm
999	Hillside soil	Near Wright's Station
1000	Hillside soil	Near Wright's Station
1075	Loam soil	Cañon in Chile's Valley
1077	Adobe soil	Hillside bordering Chile's Valley
880	Tule soil	Grizzly Island
1230	Sand hill soil	Six miles east of Antioch
1178	Tule soil	Mouth of Eel River
		SOUTH CALIFORNIA.
1281	Reddish-gray mesa soil	Experiment Station, center of main tract, near Chi
1282	Reddish-gray mesa subsoil	Experiment Station, center of main tract, near Chi
1284	Adobe, or moist soil	Experiment Station, south plot, near Chino
1406	Reddish sandy loam soil	Riverside, Arlington Heights, under Gage Canal
1408	Under-subsoil	Riverside, Arlington Heights, under Gage Canal
809	Light subsoil*	Riverside, under Riverside Canal
812	Heavy subsoil*	Riverside, under Riverside Canal
1536	Brownish loam soil	Windsor tract, Arlington Heights
1537	Reddish clay soil	Balmoral tract, Arlington Heights
1248	Valley "wash" soil	Temescal Valley, South Riverside
1251	Mesa soil	Temescal Valley, South Riverside
1246	Mesa soil	Temescal Valley, South Riverside
1253	High mesa soil	Temescal Valley, South Riverside
1249	Mesa subsoil	Temescal Valley, South Riverside
1244	Mesa soil	Temescal Valley, South Riverside
1245	Mesa subsoil	Temescal Valley, Auburndale Colony
1521	Gray sandy clay	Hillside, near Forestry station
1522	Yellow ochreous earth	Hillside, near Forestry station
1238	Bottom soil	Sweetwater Valley
1092	Gray soil	Palm Valley
506	Bottom soil*	Colorado River, near Yuma
1196	Bottom soil	Gila River, near Yuma
1197	Bottom subsoil	Gila River, near Yuma

* Analyses published in previous reports.

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II. ANALYSES OF WATERS.

A. STREAM AND LAKE WATERS.

Water from the streams of Pleasant Valley; sent by Mrs. M. E. Cleary, Coalinga, Fresno County. This water has a laxative effect upon persons drinking it for the first time, though after becoming accustomed to its use it seems to lose that effect, except in warm weather. Fruit trees and vines, and all kinds of grain and most vegetables thrive when irrigated with the water, but small shrubs and flowers sicken and die from the effects.

An examination of the water shows it to hold in solution 119.4 grains of mineral salts per gallon, consisting chiefly of sulphate of soda, or Glauber's salt, which renders it entirely unfit for domestic use, that salt being a purgative much used in veterinary practice. Its continued use by persons will induce weakness of the digestive organs, and end in chills and fever, or some kind of constitutional derangement. If used for irrigation purposes, it will also injure the plants unless applied in such a manner and in such abundance as to prevent entirely the accumulation of salts near the surface by evaporation, which practically is hardly feasible. The nature of the water fully explains the fact stated above, that while trees grow well, smaller plants (with shallower roots) are not successful. The latter have their roots entirely immersed in the soil saturated with Glauber's salt, from which they suffer; while the deep-rooted plants have the greater portion of *their* roots below the point of damage, and can thus survive and even flourish, since the neutral salt does not corrode the bark or root-crown.

Water of Tulare Lake, from near the middle (north and south), three miles from shore; stated to have been taken ten feet below the surface of the lake by a messenger sent by Mr. B. F. Moore, Tulare. The sample is slightly turbid, and has a fishy after-taste.

Water of Tulare Lake, said to have been taken on the northeast side, two miles from shore, and one half mile beyond vegetable growth, two feet below the surface of the lake, or four and one half feet above the bottom, by Mr. T. A. Coonradt, Tulare. The sample was slightly turbid.

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Water of Tulare Lake.

	Middle of Lake.		Northeast Side of Lake.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	60.16	10.30	29.77	5.10
Soluble in water after evaporation	43.46	7.44	18.82	3.22
Insoluble in water after evaporation	9.11	1.56	5.81	1.00
Organic matter and chemically combined water	7.59	1.30	5.14	.88
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	19.88	3.41	4.86	.83
Sodium chloride (common salt)	3.77	.64	4.98	.85
Sodium carbonate (sal soda)	19.81	3.39	8.98	1.54
The insoluble part consists of—				
Calcium and magnesium carbonates / Calcium sulphate (gypsum)	7.71	1.32	4.12	.71
Silica	1.40	.24	1.69	2.29

The above analyses are difficult to reconcile, particularly as to total of salts present, with those made in former years upon well authenticated samples, and probably represent only local accumulations of mixtures of fresh water with the strong water of the lake, as analyzed in 1880 and 1888. There certainly has been no such extensive change in the area of the lake as would seem to be indicated here.

Water of Lake Elsinore, San Diego County; sent by Mr. Peter Wall, Elsinore, January, 1891. The water is clear, but has a faintly brackish taste.

Water of Lake Elsinore; sent by Mr. N. Messer, Wildomar, San Diego County, January, 1890. The sample is clear and colorless.

Water of Lake Elsinore.

	1890.		1891.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	103.21	17.67	84.34	14.44
Soluble in water after evaporation	95.21	16.30	71.84	12.30
Insoluble in water after evaporation	2.75	.47	5.96	1.02
Organic matter and chemically combined water	5.25	.90	6.54	1.12
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	76.00	13.00	14.85	2.55
Sodium chloride (common salt)			43.37	7.42
Sodium carbonate (sal soda)	19.21	3.30	13.62	2.33
The insoluble part consists of—				
Calcium and magnesium carbonate / Calcium sulphate (gypsum)	2.75	.47	5.49	.08
Silica	Trace.		.47	.94

There is quite a difference in the amount of mineral contents of the two samples, that taken recently having the least amount, especially of the alkali salts. This difference, or rather diminution of the mineral matter, is due entirely to its dilution, caused by the influx of pure water from the San Jacinto River last winter, and which made the lake overflow into Temescal Valley, and seemed to make "soap" with the water of Lee's Lake, so that the creek frothed all over the riffles.

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Even with this dilution the water of Elsinore Lake is too strong in alkali salts to be used for *continued* irrigation purposes. It would do for a few years, and then the land would be "dead" with alkali—"black alkali" at that.

THE WATER SUPPLY OF THE TEMESCAL VALLEY.*

The South Riverside Land and Water Company's supply is derived from the watershed of Temescal Creek—a total of about one hundred and seventy-five square miles—mainly on the Santa Ana Range, from which deep and long cañons descend into the valley, while from the opposite steep and rocky slopes of the Temescal Range (the foot of which is closely hugged by the creek in its upper course) only a few and comparatively insignificant runlets find their way into the valley. Again, the cañons lying immediately adjacent to the colony lands of South Riverside furnish but a relatively small, though by no means insignificant, water supply, which requires storage reservoirs for the winter waters. One such has already been established at the mouth of Hagador Cañon, and excellent natural sites for large reservoirs exist near the mouth of Lord's Cañon. The cause of the relatively scanty permanent flow from these gorges is manifestly the nature of the geological formation of the hills, which, near their base, is a structureless red loam, that has materially contributed to the soils below; and farther back, the sandy clays of the older (Tertiary) beds, in which, likewise, water-shedding strata are very rare, and springs therefore scarce. Very much the same state of things prevails in several other cañons above, such as Manning's, Damron's, White's, and Anderson's; they do not reach back far enough into the rocky, central mass of the range.

Ascending the valley, Coldwater Cañon is the first that yields an important permanent flow, and still above, Mayhew, Peter Wall, and Horsethief Cañons carry streams that flow throughout the year. The width of the Temescal Valley, in this upper portion, is from one to one and a half miles between the mountain slopes; but within it there lie bodies of low hill or mesa land, dividing it lengthwise into two portions. Through the narrow one, at the foot of the eastern or Temescal Range, flows the main creek; while more or less definite "washes" mark the points where, in times of flood, the waters of the cañons find their way across the valley from the Santa Ana Mountains. These washes are formed of great masses of debris, whose material is mostly granitic sand, gravel, and often huge bowlders of the same material, as well as of black-and-white-banded siliceous schist; showing both their origin in the central rock-masses, and proving the copious rainfall of the higher portions of the Santa Ana Range. A continuous flow of water in these washes exists but rarely, and for a short time; the porous nature of the deposits readily explains the disappearance of the waters from view.

What becomes of the latter, is a question intimately connected with the valley's supply of irrigation water. A glance at a general map would seem to indicate that the Temescal Creek is but the natural continuation of the San Jacinto River, which empties into Elsinore Lake; and from the latter a conspicuous channel leads directly into the

* Abstract from a report made to the company, July, 1890.

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Temescal Valley. In other words, Temescal Creek is the natural outlet of Elsinore Lake; but actual *flow* from the lake occurs only at long intervals. It has existed in 1890 for four months, finally ceasing on or about July twenty-fifth; the last previous occurrence of such connection was in 1884; the last before that in 1864. It might be supposed that underground connection, through gravel beds, might, nevertheless, take place all the time. A close examination made of the channel between the head of Temescal Valley and the outlet of Elsinore Lake, has shown that this is not the case, since impervious clay deposits intervene at several points, where the water would have to come to the surface. Moreover, the continuous concentration of the water of Elsinore Lake by evaporation, as shown by evidence, and analysis given above, shows clearly that under ordinary conditions of rainfall Elsinore Lake has no outflow of any importance. When it occurred in 1890 the water of Temescal Creek for some time was strongly tainted, as with soap, from the admixture of the alkaline water of the lake. Upon the cessation of the surface flow from the lake the water resumed its usual character of a mountain stream. But, to the casual observer, it now appears to be (to borrow a legal phrase) "without visible means of support."

About eleven miles (on a direct line) above the townsite of South Riverside there is a long, shallow lake basin, about eighty acres in extent, called (from the first settler near by) Lee's Lake. From the lower end of this (partly tule-covered) sheet of water issues the ordinary flow of Temescal Creek, while little or no flow enters the upper end of the lake. Examination shows that the latter is fed by numerous springs (amounting in places to a continuous copious ooze for many yards) coming in from the southwest or Santa Ana side of the valley, and most abundant in front of the "washes" of Horsethief and Peter Wall Cañons. It is obviously the flow of these gorges, absorbed within the great masses of debris they have deposited between their exits from the Santa Ana Range and the course of the main creek at the foot of the opposite slope, that with slow movement feeds the lake and the flow of the creek at its outlet, which in the dry season amounts to about four hundred miner's inches.

Cienegas.—While there can be no doubt that the waters of Horsethief and Peter Wall Cañons reach Lee's Lake more or less directly through the gravel and sand beds formed by them, and are substantially continuous across the valley, the same is not true of the two cañons below, viz.: Mayhew's and Coldwater. The former, nearly two miles below Peter Wall's, is separated from it by hilly or mesa land, previously referred to, which is mainly composed of clayey strata, partly of an old formation (Miocene), practically impervious to water. The Mayhew wash crosses these hills through a narrow pass; but wells, sunk close by, show that the gravel wash is only superficial, and that a clay mass or dam cuts off any considerable underground flow from the cañon to the creek. The same condition of things prevails where the Coldwater wash occasionally pours its flood waters into Temescal Creek.

The natural result is that the debris of these two cañons have been piled up back of the clay ridges into heavy gravel beds, into which the waters are absorbed and stored, forming an extensive tract of moist or cienega land, from which water naturally bursts forth at many points in the form of copious springs, and from which, as experiment has shown, a still further supply can be drawn by artesian borings, or, as

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has actually been done, by tunneling into the cienega from a lower level. In the experimental tunnel so driven (at Riley's Cienega), a flow of twenty-five to thirty inches rushed in through a small hole, so soon as the last of the clay wall was broken through, forty feet below the surface.

The areas which may be properly designated as cienega land, showing the peculiar black soil that characterizes such spots, may be enumerated as follows:

1. The *"Compton" Cienega*, embracing about twenty acres of absolutely wet (tule) land, or one hundred and sixty acres of moist, all told, lies midway between Mayhew and Coldwater Cañons, where they approach nearest (one half mile), and but a short distance from the foot of the "clay hill" belt of the valley. From this wet land there has always been a steady surface-flow of between fifty to sixty inches. Three artesian wells have been bored within this cienega, one to the depth of three hundred, the two others to that of about one hundred and fifty feet, all in granitic gravel. There appeared to be no material increase of flow with greater depth, the discharge being steadily about twenty-five inches each from wells Nos. 1 and 2, and over twenty inches from No. 3. The water of the latter at present discharges from a pipe laid to a school house near by, twenty-five feet above the mouth of the well; the three aggregate seventy-two inches.

2. The *"Rolfe" Cienega*, distant from the preceding about one fourth of a mile southeasterly, just beyond the wash of Coldwater Cañon, has three hundred and fourteen acres of wet land, part of which is so full of springs, and with the luxuriant vegetation so dangerous for roaming cattle, that it has been fenced for safety. Four ten-inch artesian wells have been bored here to depths ranging from one hundred and twenty-five to one hundred and forty-five feet, all the time in granitic gravel. The flow of the borings here is more copious than in the Compton Cienega. Besides this, there is a considerable surface-flow, which has not been sensibly diminished by the boring of the wells, reported as amounting to as much as three hundred inches before boring the wells; this makes the total discharge from the Rolfe and Compton Cienegas about six hundred inches.

The two cienegas are connected by a pipe-line, and their joint overflows from wells and surface are gathered into a reservoir, and pass on to the Riley Cienega.

3. *Riley's Cienega* is distant about three fourths of a mile due north from the artesian wells in the Rolfe Cienega, and about seven acres in area. This small cienega, like the last, lies on the course of Coldwater Cañon wash, which here passes right at the base of the clay hills on the east side, while the same close in, within a few hundred yards, on the west also. Here (as previously mentioned) a tunnel was driven from the main pipe-line toward the cienega, with the intention of tapping it at some depth below the surface, the result being that, as stated above, a twenty-five-inch stream of water burst in through a hole about eight inches in diameter, when the clay wall was broken through into the gravel of the cienega. Nothing has since been done to increase this flow, which has risen to thirty inches at the last measurement made (July 2, 1888).

4. The *Harrington Cienega* lies two and one half miles below the Riley tract, on the course of the main Temescal Creek, which is almost lost at the upper end of the moist land, but reappears at its lower end, being

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forced to the surface by granite ledges which here confine the valley to a short gorge; at its narrowest point the latter is only three hundred feet across. The full flow of the creek passes over the granite rocks as a waterfall, of considerable volume when seen by the writer in June of the present year. The moist land above, much of which is overgrown with willows and cottonwood, is about seven acres in area. There can be no question that it is fed essentially by the main creek, which was compelled to drop its gravel in consequence of the barrier across its course. Its altitude at the lower end is eight hundred and forty-two feet.

Below the Harrington gorge, Temescal Creek gradually becomes smaller in volume as it sinks into the gravel beds, and in years of ordinary rainfall is not seen to carry any water below the bridge on the Riverside road (Magnolia Avenue). In June, 1890, however, it not only flowed past the townsite itself, but reached the Santa Ana River as a definite stream, flowing mostly along the foot of the Auburndale bluffs.

Character of the Waters—Chemical Composition.—The water of the artesian wells is limpid and cool, and very pleasant for drinking; that of Lee's Lake is, of course, more or less charged with vegetable matter derived from the tule and other growth that luxuriate in portions of the water-covered area. The subjoined analyses of samples representing the two kinds of water contributing to the South Riverside system, one taken from the largest well in the Rolfe Cienega, the other from the western margin of Lee's Lake, show their character:

Composition of South Riverside Irrigation Waters.

	Artesian—June 24, 1890.		Lee's Lake—August 31, 1890.	
	Grains per Gallon.	Parts per 10,000.	Grains per Gallon.	Parts per 10,000.
Total solid contents	13.20	2.260	14.14	2.425
Strictly mineral matter	12.00	2.054	12.25	2.147
Soluble after evaporation	*3.96*	*.679*	*2.77*	*.475*
Sodium chloride (common salt)	.55	.094	1.00	.170
Sodium sulphate (Glauber's salt)	2.11	.361	.71	.123
Sodium carbonate	.55	.093	.50	.085
Potassium sulphate	.75	.131	.56	.096
Insoluble after evaporation	*8.03*	*1.375*	*9.68*	*1.672*
Calcium sulphate (gypsum)	.88	.151	.13	.022
Calcium carbonate	4.49	.770	5.76	1.000
Magnesium carbonate	.80	.137	.82	.141
Peroxide of iron	.06	.012	.11	.020
Silica	1.80	.305	2.86	.490
Organic matter (small) and water	1.20	.205	1.68	.280

The total mineral contents of these two waters would, when mixed in equal proportions, average about twelve and one fourth grains per gallon. This, taken as a whole, is over five grains less than is contained in the water of the Los Angeles River, and less by three and one fourth grains than that in Warm Creek (the old Riverside ditch); it is almost precisely the average of the Gage artesian wells at Riverside. Inspection shows that of the total of mineral matter, only one third in the artesian water, and less than one fourth in the lake water, consists of soluble or "alkali" salts, the rest being earthy matter that always forms an accept-

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able contribution to the soil-mass. But of the permanently soluble portion a considerable part—three fourths of a grain in the artesian water—consists of a highly valuable fertilizing substance, viz.: potassium sulphate, the potash being manifestly derived from the granitic rocks and debris from which all these waters flow. While three fourths of a grain per gallon may seem a small amount, it ceases to be insignificant when multiplied by the number of gallons expected to be used on an acre of ground in the course of a year. Allowing only one inch (four-inch pressure) to ten acres, we obtain for the weight of the potash thus brought on the land twenty-seven pounds, worth, in the form of the sulphate, $1 25 wholesale, at New York. While this may not seem a very important offset to the cost of irrigation water, the fact is that there is, even thus, supplied the full amount of potash required for a heavy crop of wheat (thirty bushels), including straw, or two and one half such crops of grain, exclusive of straw, or for a five-ton crop of grapes, which draw more heavily on potash than does any other fruit. It is clear that with what is always in addition supplied by the soil, the heaviest crops expected to be grown on these lands will not render fertilization with potash necessary, so long as these waters are used in irrigating it.

Water from the Gila River, taken at different seasons and sent by Mr. Hiram W. Blaisdell, Yuma, Arizona. These samples were analyzed for the sender in order to determine whether well or river water would be best for use at different times of the year.

	Grains per Gallon.			Parts in 10,000.		
	Sample taken June 5.	Sample taken June 23.	Sample taken July 8.	Sample taken June 5.	Sample taken June 23	Sample taken July 8.
Total residue by evaporation	70.10	90.30	112.20	12.00	15.46	19.20
Soluble in water after evaporation	46.70	61.50	76.60	7.99	10.54	13.10
Insoluble in water after evaporation	17.90	22.60	22.30	3.08	3.96	3.82
Organic matter and chemically combined water	5.50	6.20	13.30	.98	1.06	2.38
The soluble part consists of—						
Sodium and potassium sulphates (Glauber's salt, etc.) Sodium chloride (common salt)	46.30	61.00	76.19	7.93	10.45	13.01
Sodium carbonate (sal soda)	.37	.50	.50	.06	.09	.09

The *insoluble part* of these waters consists of gypsum (predominating in the samples taken June twenty-third and July eighth), carbonates of lime and magnesia, and silica, with traces of iron, alumina, and phosphoric acid. This river water becomes so strong in salts during the summer as to place it beyond the pale of desirable irrigation waters. If used, the presence of carbonate of soda should be counteracted by the use of plaster (gypsum). The soil of the valley, however, is so porous that a leaching out of accumulated salts would seem to be easily effected by thorough flooding in winter.

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B. SPRING WATERS.

Water from a spring, twenty-four miles from Ukiah; sent by Mr. J. M. Robinson, Ukiah, Mendocino County. The sample is clear and colorless, and contains free carbonic acid. Its composition is:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	83.29	14.26
Soluble in water after evaporation	46.14	7.90
Insoluble in water after evaporation	37.15	6.36
Organic matter and chemically combined water	Trace.	.....
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.06	.19
Sodium chloride (common salt)	1.90	.32
Sodium carbonate (sal soda)	43.18	7.39
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	35.75	6.12
Silica	1.40	0.24

The mineral contents of this water consist almost exclusively of the carbonates of soda and of lime, the latter being kept in solution in presence of the free carbonic acid gas. By boiling, the water would be freed from the gas and the lime precipitated, thus leaving a water strongly alkaline with soda. Such a water would, however, not be palatable. The water is so highly charged with soda as to render it unfit for domestic use, but as an alkaline mineral water it is of fair strength, and if sufficiently charged with carbonic acid would, doubtless, form a palatable water of good medicinal qualities.

Water from "Mt. Ida Spring," near Oroville, Butte County; sent by Mr. Adolf Ekman. "Carbonic acid and sulphuretted hydrogen gases constantly bubble up from the bottom of the spring; and cattle will swim the creeks in order to get a drink of the water, evidently appreciating its properties." The sample is clear, colorless, and tasteless. It contains a small amount of free carbonic acid gas, but no sulphuretted hydrogen was perceptible. Its composition was found to be:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	74.30	12.72
Soluble in water after evaporation	56.08	9.60
Insoluble in water after evaporation	12.38	2.12
Organic matter and chemically combined water	5.84	1.00
The soluble part consists of—		
Sodium sulphate (Glauber's salt)	31.11	5.32
Sodium chloride (common salt)	21.26	3.64
Sodium carbonate (sal soda)	3.71	.64
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	9.93	1.70
Silica	2.45	.42

The mineral content of this water is large, and the large amounts of Glauber's salt and common salt make it unfit for domestic use. It is a mild saline purgative mineral water, and its *constant* use is to be avoided, both by man and cattle; the latter are doubtless attracted by its saline nature.

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Water from a mountain spring near Cloverdale, Sonoma County; sent by Mr. G. Hunziker, of Cloverdale. The sample is clear and contains a small amount of free carbonic acid. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	6.08	1.04
Soluble in water after evaporation	2.00	.34
Insoluble in water after evaporation	3.44	.59
Organic matter and chemically combined water	.64	.11
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.22	.04
Sodium chloride (common salt)	.54	.09
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates Calcium sulphate (gypsum)	2.62	.45
Silica	.82	.14

This is an exceptionally pure water, containing a very small amount of mineral matter, being less than half of what is commonly found in the waters of that region. Among the mineral ingredients there is a comparatively large amount of carbonate of soda.

Mineral water from near Martinez, Contra Costa County; sent by Mr. Wm. J. Young. The spring from which the water was taken is situated in the bottom of a deep cañon gulch. The sample is clear and emits an odor of sulphuretted hydrogen, which is present in small quantity. The water has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	114.13	19.54
Soluble in water after evaporation	78.21	13.39
Insoluble in water after evaporation	28.50	4.88
Organic matter and chemically combined water	7.42	1.27
The soluble part consists of—		
Sodium and potasium sulphates (Glauber's salt, etc.)	68.39	11.71
Sodium chloride (common salt)	7.36	1.26
Sodium carbonate (sal soda)	2.48	.42
Magnesium sulphate (Epsom salt), small amount.		
The insoluble part consists of—		
Calcium and magnesium carbonates Calcium sulphate (gypsum)	22.66	3.88
Silica	5.84	1.00

The water is quite strongly mineral—quite ten times as much as should be the case for domestic use. Its character is that of a saline purgative, resembling somewhat the waters of Byron Spring. It contains a very large amount of Glauber's salt, a good deal of common salt, with a large amount of lime and magnesia carbonate and silica.

Water from a spring on Smith's Ranch, Alhambra Valley, four miles from Martinez, Contra Costa County; sent by Mr. L. M. Smith, Martinez:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	659.69	112.94
Soluble in water after evaporation	653.86	111.94
Insoluble in water after evaporation	5.83	1.00
Organic matter and chemically combined water, little.		
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	57.12	9.78
Sodium chloride (common salt)	399.77	68.44
Sodium carbonate (sal soda)	6.19	1.06
Magnesium chloride	8.65	1.48
Calcium chloride	182.13	31.18
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	5.37	.92
Silica	.46	.08

The very large amount of mineral contents condemns this water at once for domestic purposes. As a mineral water it is very strongly saline, with also nearly half as much chloride of calcium. The most delicate tests showed the presence of extremely small amounts of lithia. Its value for medicinal purposes is in great doubt.

Water from the tunnel in the hill at the Deaf, Dumb, and Blind Asylum, Berkeley; sent by Prof. W. Wilkinson, Superintendent.

Water from Strawberry Cañon; in use by the University (from a previous report, for comparison). Both waters are clear, colorless, and tasteless.

	Asylum.		University.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	19.22	3.29	14.21	1.01
Soluble in water after evaporation	8.24	1.41	5.22	.37
Insoluble in water after evaporation	10.98	1.88	8.99	.64
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	4.29	.74	.27	.02
Sodium chloride (common salt)	2.71	.46	1.54	.11
Sodium carbonate (sal soda)	1.24	.21	.29	.02
Sodium silicate			3.12	.22
The insoluble part consists of—				
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	6.01	1.03	8.81	.62
Silica	4.97	.85		
Phosphate of iron and alumina			.18	.02

A comparison of the two waters, respectively, from the Asylum and University water-supply, is of interest in showing that while that of the former has much the larger amount of mineral matter, nineteen to fourteen grains, it is also much softer than that of the University, because of the less content of earthy matter; only six grains of the total nineteen of the Asylum water go to produce the "hardness," while nearly nine grains of the total fourteen of the University act in that direction. Moreover, there is four times as much carbonate of soda in the former (1.24 against 0.29 in the University water); and as sal soda is used for softening hard waters, that is a point in favor of the Asylum water. Both are, of course, good waters for all domestic uses.

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Mineral water, taken from a spring six miles from Montecito Valley, Santa Barbara County; sent by Hon. E. H. Heacock. The sample was clear golden yellow in color, with a strongly bitter taste, and without odor.

"As a purgative water this is very effective and not painful in the least. It was a medicinal water used by the native Indians as a purgative and cure for most of their ills. It is estimated that the spring yields some five hundred gallons of water per day."

An analysis gave the following result:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	2,224.64	380.86
Soluble in water after evaporation	1,820.44	311.66
Insoluble in water after evaporation	83.88	14.36
Organic matter and chemically combined water	320.32	54.84
The soluble part consists of—		
Potassium sulphate	6.16	1.06
Sodium sulphate (Glauber's salt)	152.58	26.12
Sodium chloride (common salt)	242.88	41.58
Sodium carbonate (sal soda)	36.57	6.26
Magnesium sulphate (Epsom salt)	966.59	165.48
Magnesium nitrate	415.66	71.16
The insoluble part consists of—		
Calcium sulphate (gypsum)	57.12	9.78
Calcium phosphate	Trace.	Trace.
Magnesium carbonate	26.76	4.58

The composition of this water is very unusual. There are waters as strong as this in Epsom salt and the other saline ingredients given, but the extraordinary quantity of nitrate of magnesia shown here is quite out of the usual way, and would hardly be looked for outside of the nitre beds of Bolivia or Nevada.

In general saline strength the water is about equal to that of sea water. It is needless to say that with over fourteen hundred grains of magnesian salts per gallon it must be highly purgative, as Mr. Heacock says; but the cooling effect of the nitre may have something to do with the mildness or painlessness of the action referred to. As a very concentrated medicine, it should be used with great caution by patients. The yellow tint is doubtless due to dissolved organic matter of some kind, not easily identified; it is evidently dissolved in the carbonate of soda.

It would be highly interesting to ascertain the exact origin of this water, and the conditions under which so much nitre can be formed in the coast climate of Santa Barbara.

Waters from four springs in the cañons of Piru Rancho, near Camulos, Ventura County; sent by David C. Cook, Esq. The water from Spring No. 3 is colorless, and somewhat flattish to the taste. There was a slight evolution of carbonic acid when boiled. Spring water No. 4 is from the same locality, but sent more recently; the sample is clear, tasteless, and odorless.

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	Spring No. 1.	Spring No. 2.	Spring No. 3.	Spring No. 4.	
	Grains per Gallon.			Grains per Gal.	Parts in 10,000.
Total residue by evaporation	85.10	181.60	57.25	61.68	10.56
Soluble in water after evaporation	47.31	87.70	21.62	24.19	4.14
Insoluble in water after evaporation	30.69	70.54	27.63	29.90	5.12
Organic matter and chemically combined water	7.10	23.36	8.00	7.59	1.30
The soluble part consists of—					
Sodium and potassium sulphates (Glauber's salt, etc.)				9.93	1.18
Sodium chloride (common salt)				1.84	.32
Magnesium sulphate (Epsom salt)				15.42	2.64
The insoluble part consists of—					
Magnesium carbonate				3.43	.59
Calcium carbonate, small amount.					
Calcium sulphate (gypsum)				21.92	3.75
Silica				4.55	.78

The *soluble part* of these waters consists of sulphates and bicarbonates of potash and soda, with a small amount of common salt. The *insoluble part* is principally gypsum, with carbonates of lime and magnesia, and a very little silica; traces of iron are present. The waters are very nearly of the same character, although of different degrees of strength. None of them fall within the limits of what is usually considered potable waters. No. 2 is unfit for any but medicinal use, permanently. No. 1 might, with proper precautions, be used for irrigation. No. 3, with its 21.6 per cent of permanently soluble alkali, is just admissible for ordinary irrigation. It is still two and one half times stronger than the Los Angeles River water, and six times stronger than that of Kern River; and it will necessitate special modes of culture to render it permanently innocuous. But if forming only a part of the supply of the reservoir otherwise filled with rain water, it may, of course, be diluted down to the regulation strength.

The water of the sample sent more recently (No. 4) contains a large amount of mineral matter, the greater part of which is gypsum and Epsom salt, with some Glauber's salt; it is therefore quite purgative in its nature, and, in its raw state, unfit for domestic uses; it may be improved for drinking by treatment with lime water, and for washing by the use of sal soda. It will do fairly well for irrigation.

Mineral water from the mountains some twenty-five miles east of San Buenaventura, Ventura County, at an altitude of about one thousand eight hundred feet above the sea; sent by Mr. José G. Moraga, Santa Barbara. The sample sent is clear and colorless, but intensely saline to the taste. It contains 4,544 grains of residue per gallon, consisting mainly of common salt, with chlorides of calcium and magnesium in small quantities. There are also some carbonates of lime and magnesia, the former predominating, in the insoluble portion of the residue. This water is exceptionally strong in mineral contents, and of course is totally unfit for domestic use or for irrigation purposes, and too nearly pure salt water to promise unusual medicinal virtues.

Water from a spring six miles east of Sumner, Kern County; sent by Mr. John Barker, Sumner.

"The spring issues from under a bluff three hundred feet in height, and flows into Kern River, which lies about ten feet below it. A continuous stream of gas-bubbles rises up through the water to the surface.

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The bluff is composed of a regular stratum of sedimentary deposit, which has evidently been formed at the bottom of an ancient sea, as fossil remains are found all through it. A heavy deposit of white sulphur exists for a long distance above and below the spring. The temperature of the spring is 70 degrees Fahrenheit. Many persons with malarial troubles have used the water, and claim to have been benefited."

The sample is clear, has a saline taste, and an odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	199.18	34.10
Soluble in water after evaporation	186.92	32.00
Insoluble in water after evaporation	7.30	1.25
Organic matter and chemically combined water	4.96	.85
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	15.72	2.70
Sodium chloride (common salt)	142.72	24.43
Sodium carbonate (sal soda)	28.48	4.87
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	4.67	.80
Silica	2.63	.45

The character of this water is that of a saline sulphur water of considerable strength. The chief ingredient is common salt; and, with the carbonate and sulphate of soda, it forms a composition that might be beneficial in many cases. But its exact uses must be pointed out by the doctors.

Water, stated to be from the water supply of the Soldiers' Home,* located between Los Angeles and Santa Monica, about three miles northwest of "The Palms" Station, Los Angeles County. The water rises in a loose sandstone formation in the Santa Monica Mountains. Sent by T. F. Laycock, Los Angeles.

	Grains per Gallon.	Parts in 10,000.
Total residue from evaporation	66.00	11.30
Soluble in water after evaporation	29.35	5.03
Insoluble in water after evaporation	25.85	4.42
Organic matter and chemically combined water	10.80	1.85
The soluble part consists of—		
Sodium chloride (common salt)	4.60	.79
Sodium and potassium sulphates (Glauber's salt, etc.)	7.32	1.34
Sodium carbonate (sal soda)	2.48	.42
Magnesium sulphate (Epsom salt)	14.45	2.48
The insoluble part consists of—		
Calcium sulphate	12.03	2.04
Calcium carbonate	9.90	1.69
Magnesium carbonate	2.72	.49
Peroxide of iron	Trace.	
Silica	1.20	.20

The high mineral contents of this water condemn it for domestic use, since Epsom salt, Glauber's salt, and gypsum comprise the chief ingredients and make it highly purgative in its nature. Even treatment with

*The authenticity of this sample is called in question by the authorities of the Home. On this point the station has no other information than that given by the sender; but, whatever may be its derivation, such water is most positively unfit for domestic use.

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lime, as described in previous reports, would leave the water objectionable, though the removal of magnesia in that way would be a material improvement. The water is, therefore, unfit for habitual use, and if so used will necessarily produce serious disorders. It can be used for irrigation in sandy soils that are well drained, but in clay soils it will soon cause "alkali."

All the waters draining from the "rotten sandstone" of the region will probably be of the same nature, and wells should be bored down into the clay formations to get a reasonably good water.

Water and gas from a spring near Escondido, San Diego County; sent by Mr. J. W. Turrentine.

"The spring is located almost in the bed of Escondido River, not in the channel, but manifestly has no connection with the water of the river. The water seems to rise through a fissure in the granite from an unknown depth, and flows about one half of a miner's inch. The water, when entirely free from contamination, is soft, and apparently contains sulphur. Large quantities of gas or air escape continually; sometimes large bubbles are sent up, a few of which would fill a pint bottle. During the past three years there seems to have been no change either in the quantity or quality of the water."

The sample is clear, colorless, and tasteless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	24.94	4.27
Soluble in water after evaporation	15.71	2.69
Insoluble in water after evaporation	6.96	1.19
Organic matter and chemically combined water	2.27	.39
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	9.08	1.56
Magnesium sulphate (Epsom salt), small amount.		
Sodium chloride (common salt)	4.77	.82
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates Calcium sulphate (gypsum)	5.96	1.02
Silica	1.00	.17

The gas that is given off is nitrogen, entirely neutral, and of no effect. The mineral contents are too small to entitle it to the name of mineral water, though such as there are will probably act as a gentle purgative on some persons; this property may also prevent its use for domestic purposes.

COMMON WELL WATERS.

Well water; sent by Dr. W. N. Finney, Roseville, Placer County. The water is from a bored well; the sample sent is clear, with a slight odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue from evaporation	39.25	6.72
Soluble in water after evaporation	26.58	4.55
Insoluble in water after evaporation	9.75	1.67
Organic matter and chemically combined water	2.92	.50
Silica	3.63	.62

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More than two thirds of the soluble part consists of the sulphates of soda and potash, the rest comprising bicarbonate of soda and common salt, the former predominating.

The water is slightly purgative, owing to the presence of Glauber's salt, which, with the carbonate of soda, makes up the effective portion of the contents. It would hardly do for daily use, but would be useful medicinally in certain cases of disease.

Well water; sent by Mr. Dana Perkins, Rocklin, Placer County.

"The well is sunk in soft granite to a depth of thirty feet, to a hard granite bowlder, over which a small stream of water runs in; water also seeps in at about three feet from the bottom."

The sample is clear, colorless, and tasteless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	18.40	3.15
Soluble in water after evaporation	5.84	1.00
Insoluble in water after evaporation	8.47	1.45
Organic matter and chemically combined water	4.09	.70
Silica	4.21	.71

The soluble part consists chiefly of common salt, with small amounts of sulphates and carbonates of the alkalies. The insoluble part consists of silica with considerable gypsum, and small quantities of carbonates of lime and magnesia. The water is good for both domestic and irrigation purposes.

Well water; sent by Mr. A. H. Grossman, Napa. The water is clear, and has an odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue after evaporation	12.15	2.06
Soluble part after evaporation	1.75	.30
Insoluble part after evaporation	7.77	1.33
Chemically combined water and organic matter	2.63	.45
The soluble part consists of—		
Sulphate of soda and potash (Glauber's salt)	.04	.01
Carbonate of soda (sal soda)	.62	.11
Sodium chloride (common salt)	1.09	.18
The insoluble part consists of—		
Carbonate of lime and magnesia Sulphate of lime	1.29	.22
Silica	6.48	1.11

The only unusual thing about this water is its high content of silica, which probably causes it to turn turbid in a peculiar way, and to incrust vessels. It possesses no medicinal virtue, and is simply a good water for domestic use. It resembles very closely that from the well of Mr. Zierngibl, of St. Helena (given in a previous report), both in total constituents and in the relative amounts of each.

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Well water; sent by Mr. Rothwell Hyde, St. Helena, Napa County. The water is clear, colorless, and tasteless. It has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	8.29	1.42
Soluble part after evaporation	1.17	.20
Insoluble part after evaporation	5.54	.95
Chemically combined water and organic matter	1.58	.27
Silica	4.26	.73

This water is *very* weak in its mineral constituents, a little more than one half of which is silica. There is present about half a grain each of common salt and bicarbonate of soda, a very little Glauber's salt, and a little more than one grain of carbonate of lime and magnesia in a gallon of the water.

This water, like that from the well of Mr. Zierngibl, of St. Helena, and Hunziker's Spring, Cloverdale (see above), is quite peculiar, in that its chief mineral constituent is silica, while the permanently soluble portion is very small. If the insoluble portions were removed, by boiling or other means of precipitation, the water would be almost chemically pure. It is very good for domestic and all other uses.

Well water; sent by Mr. E. Younger, San José, Santa Clara County. "The water has a flow of six inches over a tin pipe from a well that is four hundred and fifty feet deep, the lower one hundred and eighty feet being through a rotten clay with streaks of rust, and inclosing large brownish-colored bowlders. The water when allowed to drip for any length of time upon substances, forms upon them a brownish deposit looking like rust; and when confined for some time in a closed vessel it acquires a very strong odor. Tender flowers will not stand being watered with it."

The sample received was clear, colorless, and odorless; also free from iron. An analysis shows it to have the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	20.15	3.45
Soluble in water after evaporation	8.18	1.40
Insoluble in water after evaporation	8.47	1.45
Organic matter and chemically combined water	3.50	.60
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.61	.45
Sodium chloride (common salt)	.68	.11
Sodium carbonate (sal soda)	4.89	.84
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	7.01	1.20
Silica	1.46	.25

The water agrees remarkably with those examined from artesian wells between San José and Alvarado, both as to amount of mineral matter and its nature. The predominance of carbonate of soda is characteristic of all the artesian waters coming from near the center line of the Santa Clara Valley. There is nothing against the water for domestic use; for irrigation, the carbonate of soda should be counteracted by the use of land plaster from time to time; but it is, in general, a very good

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water. The coloration spoken of arises from a deposition of a mixture of silica and a little iron rust on the surface of tin or other articles that will show such change readily. Any water containing carbonate of soda is liable to put vegetable matter into a condition of offensive (lacto-butyric) fermentation, and hence the odor alluded to above. It will only happen when left stagnant, and means nothing to the detriment of the healthiness of the fresh water for drinking or other domestic purposes.

Water from a bored well near Cupertino, Santa Clara County; sent by Mr. F. Spangenburg.

"The well, seven inches in diameter, was bored on a wet spot to a depth of fifty-two feet, through ten feet of alluvial soil, thirty-six feet of yellow clay, impervious to water, but easily penetrated, three feet of blue clay, and three feet of blue gravel and stones. The well is situated at the outlet of a small ravine running north and south; the land on the east side of the ravine is hilly, and has a dark, clayey soil, mixed with enough gravel to prevent its being sticky. The land on the west side is gravelly. The watershed of this ravine covers fifteen or twenty acres. The wells on the adjoining places all have good water. The water in the pipe of this well stands fifteen inches above the surface of the ground, and is not influenced by wet or dry weather."

The sample of water sent is clear, colorless, and odorless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	46.73	8.00
Soluble in water after evaporation	12.85	2.20
Insoluble in water after evaporation	23.60	4.04
Organic matter and chemically combined water	10.28	1.76
Silica	8.52	1.47

The soluble part consists chiefly of common salt, with small amounts of the sulphates and carbonates of the alkalies, and a very small part of sulphate of magnesia (Epsom salt). The insoluble part consists chiefly of the carbonates of lime and magnesia, with some gypsum and silica. For domestic uses this water is but very slightly saline, but is somewhat hard from the presence of so much lime, etc. The latter could be removed by boiling or treatment with lime (see previous report), leaving behind only an unobjectionable amount of common salt. The water is quite well adapted to irrigation purposes, the lime and magnesia being advantageous, especially upon the clayey lands. The salt, while generally objectionable on such lands, is too little in amount to work any injury.

Well water from four miles southwest of Fresno; sent by Mr. I. F. Moulton, San Francisco. The water was taken at a depth of six feet (bottom water), and contained some suspended matter. The sample is clear and colorless, but saline to the taste.

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	84.58	14.48
Soluble in water after evaporation	73.01	12.50
Insoluble in water after evaporation	6.89	1.18
Organic matter and chemically combined water	4.68	.80
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	60.63	10.38
Sodium chloride (common salt), chiefly		
Sodium carbonate (sal soda)	12.38	2.12
The insoluble part consists of—		
Calcium and magnesium carbonates	3.85	.66
Calcium sulphate (gypsum)		
Silica	3.40	.52

The water is quite saline in character, its mineral contents comprising chiefly common salt, with a considerable amount of Glauber's salt, and a small amount of sulphate of potash. There is also a considerable quantity of gypsum present. The water is unfit for either domestic or irrigation purposes, and when evaporated at the surface will produce "white alkali."

Well water, from the San Joaquin Valley Experiment Station, Tulare County; taken in December, 1889, and November, 1890. The samples sent were clear and colorless.

	Taken in 1889.		Taken in 1890.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	11.45	1.96	11.97	2.05
Soluble in water after evaporation	2.78	.48	2.92	.50
Insoluble in water after evaporation	8.11	1.39	7.59	1.30
Organic matter and chem. com. water.	.56	.09	1.46	.25
The soluble part consists of—				
Sodium and potassium sulphates	.44	.08	.80	.14
Sodium chloride (common salt)	.39	.07	.27	.04
Sodium carbonate (sal soda)	1.95	.33	1.85	.32
The insoluble part consists of—				
Calcium and magnesium carbonates	6.72	1.15	4.96	.85
Calcium sulphate (gypsum)				
Silica	1.39	.24	2.63	2.05

This water is remarkably weak in mineral contents, coming, as it does, from an alkali region. The ingredients are chiefly carbonates of lime and magnesia, but hardly in sufficient amounts to make the water "hard;" its saline contents are remarkably low. It is a good drinking water. Here, as elsewhere, surface water should be strictly excluded from bored wells, as it is intensely alkaline.

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Water from a sump, fourteen feet deep, in the northwest (alkali) corner of the San Joaquin Valley Experiment Station grounds, near Tulare. The water is somewhat turbid, slightly alkaline to test paper, but with no odor or taste. This sump was dug with a view to testing the practicability of leaching out the alkali in the soil above, by flooding with water from the bored well of the station, which draws upon the supply found in gravel at depths from forty-five to sixty feet. The analysis of this water is given above.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	38.32	6.56
Soluble in water after evaporation	20.62	3.53
Insoluble in water after evaporation	12.79	2.19
Organic matter and chemically combined water	4.91	.84
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	8.90	1.52
Sodium chloride (common salt) and some nitrate	6.77	1.16
Sodium carbonate (sal soda)	4.95	.85
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum), a little	7.88	1.35
Silica	4.91	.84

As this sump is located in the "alkali corner" of the station grounds, in the bottom of a slough into which the surface water drains, it is probable that this water sample is stronger in alkali than the surface water at other points would be found to be. As it stands, however, the large percentage of mineral matter in this water renders it unfit for either irrigation or domestic use. The saline sulphates would soon prove injurious to man, while the carbonate of soda would produce "black alkali" on lands irrigated with the water. It is therefore desirable to exclude this surface water from the wells bored for either domestic or irrigation supply, as in fact is usually done in the region. As will be seen, its mineral contents exceed that of the well water over three times.

Water from a gas well, six miles east of Sumner (Bakersfield), Kern County; sent by Mr. John Barker.

"The well is situated on the bank of Kern River, some fourteen feet above low-water level, and three hundred yards from a gas and sulphur spring. The gas from the latter, collected in a reservoir three feet in diameter, and twelve feet in height constructed for the purpose, is sufficient to furnish one burner with a continuous supply, burning with a bright clear flame without smoke or odor. The well, ten inches in diameter, has been bored to a depth of fifty-three feet. The formation, from the surface down, is a sedimentary one, filled with marine fossils and petrifactions. The well was bored without difficulty for the first forty feet, when we encountered strata of what seemed to be a water formation of limestone filled with marine shells, and from three to twelve inches thick each; between these strata we find the same softer formation that exists near the surface (chalky rock). After penetrating this for thirteen feet a double casing of iron was put in. At the depth of twenty-two feet a strong flow of very strong sulphur water was struck, that rose four feet above the surface, and ran a stream over the top of the pipe-casing, equal to about three miner's inches; the water had a temperature of 80 degrees Fahrenheit, and is much stronger than

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in the spring. The casing was then forced down twenty-two feet farther, but the water comes up with about the same volume on the outside of the casing. When the water was first struck at twenty-two feet there also came a very strong flow of gas, sufficient, I should think, to supply a large house with light and fuel."

The sample of water is clear, and has the odor of sulphuretted hydrogen. An analysis shows the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	168.38	27.97
Soluble in water after evaporation	147.48	25.25
Insoluble in water after evaporation	9.76	1.67
Chemically combined water and organic matter	6.14	1.05
The soluble part consists of—		
Sulphate of soda and potash (Glauber's salt)	22.99	3.95
Sodium chloride (common salt)	100.97	17.28
Bicarbonate of soda (sal soda)	23.52	4.03
The insoluble part consists of—		
Carbonate of lime and magnesia	5.55	.95
Silica	4.21	.72
Sulphuretted hydrogen, 2.73 cubic inches per gallon; free carbonic acid, very small amount.		

The character of the above is that of a strongly saline sulphur water. Without the sulphur it would be very much like a great deal of the alkali water that runs in some of the streams of Kern, San Luis Obispo, and Ventura Counties. With the sulphur, it may prove worth developing for curative purposes if the latter proves constant and strong. It is, of course, altogether too strongly mineral for domestic use.

Well water from Miramonte Colony; sent by Mr. George A. Raymond, Miramonte, Kern County.

"The well is twenty-two feet deep, and the water rises to within seven feet of the surface. A flow was struck at about thirteen feet, but the quantity was very small."

The sample is clear and colorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	8.18	1.40
Soluble in water after evaporation	4.67	.80
Insoluble in water after evaporation	2.34	.40
Organic matter and chemically combined water	1.17	.20
Silica	1.11	.19

Bicarbonate of soda is the chief ingredient of the soluble portion of the residue, the sulphates of soda and potash, with a little common salt, making up the remainder. The insoluble portion is about evenly divided between silica, on the one hand, and the lime and magnesia salts on the other. Altogether, it is a very good water for domestic use. It is a little purer than the Kern River water.

Well water, from a well twelve feet deep, on Sec. 3, T. 26, R. 23 E., northwest of Bakersfield, Kern County; sent by Mr. John S. Hittell, San Francisco. The water, on evaporation, was found to contain 1669.4 grains per gallon, which renders it entirely unfit for either domestic use or for irrigation purposes, being nearly two hundred times stronger than

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Kern River water, and the ingredients almost wholly saline. Here, as at Tulare City, the surface waters should evidently be excluded from the wells bored for either domestic or irrigation supply.

Residues from water from bored wells, respectively on the places of Messrs. Connor and Willis Carter, near Livermore Ranch, Kern Island, Kern County. The residues were furnished by Mr. Carter.

	Connor's Place.		Carter's Place.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	*3.04	.521	10.28	1.76
Soluble in water after evaporation	2.09	.358	5.86	1.00
Insoluble in water after evaporation	.61	.104	2.76	.47
Organic matter and chemically combined water	.34	.059	1.66	.28
Silica	.52	.088	1.52	.26

The water of each of these wells is very weak in its contents of mineral matter, that of Mr. Connor being especially so. In each the soluble alkali salts predominate, and in each the silica comprises the largest proportion of the insoluble part of the residue, though in that of Mr. Carter's well it is nearly equaled by the carbonates of lime and magnesia. In Mr. Connor's well the sulphates of soda and potash comprise nearly one half of the entire residue, or a little more than one grain per gallon, carbonate of soda being next. In that of Mr. Carter there is a little more common salt than of the sulphates of soda and potash, and the two make nearly one half of the entire residue.

The exceptional purity of these waters is quite remarkable, considering that the surface of the country is so commonly charged with alkali.

Water from a bored well in the Mojave Desert, about six miles east of Mojave, Kern County; sent by Mr. B. Marks, of San Francisco. The water was taken at a depth of one hundred and eighty-five feet, at which it was struck in large volume, rising twelve feet. When taken from the sand-pump it was thick and yellow, on account of the churning motion of the auger; it was allowed to settle and the water drawn off.

"The material penetrated by the well was a dry cement gravel, with layers of clay, and this has continued from the surface down to the depth of three hundred feet. There are no surface indications of alkali in that region."

The sample is clear, colorless, and tasteless; the analysis showed the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	20.26	3.47
Soluble in water after evaporation	4.20	.72
Insoluble in water after evaporation	11.62	1.99
Organic matter and chemically combined water	4.44	.76
Silica	6.30	1.07

The soluble portion consists of carbonate and chloride of sodium, with a small amount of sulphate of potassium. The insoluble part con-

* From data reported by Mr. Connor; probably too low.

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sists mainly of silica, with a considerable quantity of lime carbonate, and a small amount of gypsum and carbonate of magnesia. This water is "hard" in character, from the rather large amount of lime and magnesia; these can be readily removed by boiling, or by treatment with lime, as recommended in a former report. The water is admirably suited for irrigation, and good for domestic use.

Well water; sent by Mr. F. C. Howard, Carisa Plains, San Luis Obispo County.

	Grains per Gallon.	Parts in 10,000.
Total solid residue by evaporation	348.31	59.63
Soluble part after evaporation	230.14	39.40
Insoluble part after evaporation	74.65	12.78
Chemically combined water and organic matter	43.52	7.45
The soluble part consists of—		
Sulphate of soda (chiefly), with an appreciable amount of sulphate of magnesia, and a small amount of sulphate of potash	216.20	37.02
Common salt	9.54	1.63
Bicarbonate of soda	4.40	.75
The insoluble part consists of—		
Carbonates of lime and magnesia and sulphate of lime (gypsum)	73.25	12.54
Silica	1.40	.24

The presence of so large an amount of the soluble sulphates of soda (Glauber's salt), magnesia (Epsom salt), and potash makes this water very strongly purgative, and entirely unfit for domestic purposes. With care, it can be used as a purgative medicine in certain diseases.

Well water, from a well on the San Juan Ranch; sent by Mr. William Kelly, Cholame, San Luis Obispo County. The water is clear and colorless, and has a strong odor of sulphuretted hydrogen. It has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	553.04	94.68
Soluble in water after evaporation	407.24	69.72
Insoluble in water after evaporation	70.21	12.02
Organic matter and chemically combined water	75.59	12.94
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	372.60	63.78
Sodium chloride (common salt)	27.21	4.67
Sodium carbonate (sal soda)	7.43	1.27
The insoluble part consists of—		
Calcium and magnesium carbonates Calcium sulphate (gypsum)	68.22	11.68
Silica	1.99	.34

This water is strongly medicinal in its character, its mineral ingredients consisting very largely of Glauber's salt, with much common salt, thus making it a saline purgative of considerable strength. It is entirely unfit for either domestic use or irrigation purposes.

Well water, from the west end of Ojai Valley; sent by Mr. K. P. Grant, Nordhoff, Ventura County. The sample is clear, colorless, and odorless, and has the following composition:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	24.18	4.14
Soluble in water after evaporation	8.47	1.45
Insoluble in water after evaporation	10.17	1.74
Organic matter and chemically combined water	5.54	.95
Silica	3.16	.54

The soluble portion is composed of a little more than three and one half grains of bicarbonate of soda, and of two and one half grains each of common and Glauber's salt. The insoluble portion comprises, besides the silica, seven grains of lime and magnesia carbonates and sulphates; these make the water "hard," but they can be precipitated by boiling, thus reducing the soluble constituents to 8.47 grains per gallon. This can also be done by the lime treatment, given on page 12 of the Report on Waters, etc., for 1886–1889.

This water is therefore quite within the received limits of good potable waters, and can be readily still further softened and purified.

Waters from the wells and streams of Nordhoff, Ojai Valley, Ventura County; sent by the Nordhoff Board of Health, for examination as to purity, it being the supposed cause of the sporadic occurrence of typhoid fever in that town, which obtains its water supply both from wells and from hydrant water conveyed from the mountains by pipe.

"*No. 1* is water from the hydrant or pipe. The stream from which it is taken is quite small (only about four inches at this season of the year, viz.: December).

"*No. 2* is from a well belonging to a family, two members of which are affected with the fever. This well is thirty-two feet deep, and has eighteen feet of water in it. The strata through which it is bored are as follows: Sandy soil, nineteen feet; gravel, two feet; red clay, six feet; gravel with water, three feet; red clay, two feet.

"*No. 3* is from another well belonging to a family, four members of which have the fever. The depth of this well is eighteen feet, with the following strata: Adobe soil, six feet; sand and gravel, twelve feet.

"*No. 4* is from a small stream, upon which is located a slaughter-house, which furnishes the town with meat. The cattle drink this water, and it is used also about the slaughter-house and on the meat at the time of killing."

	Total Solids.		Ammonia. Parts per 1,000,000.		
	Grains per Gallon.	Parts in 10,000.	Free.	Albuminoid.	Total.
No. 1—Hydrant water	46.50	7.96	.032	.036	.068
No. 2—Well water	70.09	12.00	.069	.064	.133
No. 3—Well water	43.22	7.40	.200	.200	.400
No. 4—Stream water	54.32	9.30	.050	.100	.150

All these waters contain a somewhat excessive amount of mineral salts; No. 2 more than *any* water for domestic use should have.

The determination of ammonia represents the greater or less contamination with the products of animal and vegetable decay. In Nos. 1 and 2 this does not exceed the limit usually allowed. No. 3 exhibits a

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very decided and inadmissible excess of albuminoid contamination, and is not fit for either human or animal consumption. Water No. 4 is close to the allowable limit, and, if taken at a time when there was no special cause for contamination from the operations of the slaughter-house, is to be considered suspicious.

An analysis of the residue from well No. 3, whose water contains the greatest amount of ammonia, gave the following results:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	43.22	7.40
Soluble in water after evaporation	19.39	3.32
Insoluble in water after evaporation	18.10	3.10
Organic matter and chemically combined water	5.73	.98
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	10.35	1.77
Sodium chloride (common salt)	4.09	.70
Sodium carbonate (sal soda)	4.95	.85
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	13.31	2.28
Silica	4.79	.82

There is in this water enough of the soluble alkali sulphates (Glauber's salt, etc.) to render it somewhat debilitating to the system, if used constantly, and thus render more effective and dangerous the rather large amount of albuminoid ammonia present. The presence of so much common salt at the same time, suggests at once its contamination with sewage.

Altogether there is little doubt that the prevalence of typhoid fever in the two families was the result of the use of the water from their respective wells, and especially so from well No. 3.

Well water; sent by Mr. J. William James, Los Angeles.

"The well is one hundred and two feet deep, and cased with double iron pipe. Water was reached at seventy-five feet; boring was continued through a small bed of clay, then through eighteen feet of fine sand, and finally through clay again; the water then rose in the pipe to within twenty feet of the surface."

The sample of water sent is clear, colorless, and tasteless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total solid residue by evaporation	39.88	6.82
Soluble part after evaporation	13.43	2.30
Insoluble part after evaporation	15.07	2.58
Combined water and organic matter	11.33	1.94
Silica	2.92	.50

The soluble part consists of about equal portions of common salt, bicarbonate of soda, and sulphates of soda and potash; the insoluble part contains about three grains of silica per gallon, the rest being the carbonates of lime and magnesia, and sulphate of lime (gypsum). This is a very hard water, and likely to disagree with many persons, unless purified by boiling, or by treatment with lime, as recommended in the previous report on waters, etc.

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Well water, from the Blaisdell Ranch, in the valley of Gila River; sent by Mr. Hiram W. Blaisdell, Yuma, Arizona.* The waters are clear and tasteless, but slightly flattish on the tongue.

	Grains per Gallon.				Parts in 10,000.			
	Sample taken June 6.....	Sample taken June 23.....	Sample taken Aug. 9.....	Sample taken Dec. 15.....	Sample taken June 6.....	Sample taken June 23.....	Sample taken Aug. 9.....	Sample taken Dec. 15.....
Total residue by evaporation	41.6	44.2	42.5	37.3	7.12	7.56	7.28	6.38
Soluble in water after evaporation.....	30.4	32.2	30.7	29.1	5.20	5.52	5.24	4.98
Insoluble in water after evaporation ..	8.8	8.9	9.4	5.0	1.48	1.52	1.60	.86
Organic matter and combined water ..	2.4	3.1	2.4	3.2	.44	.52	.44	.54
The soluble part consists of—								
Sodium and potassium sulphates.. Sodium chloride (common salt).....	26.7	28.5	26.9	22.6	4.76	4.88	4.57	3.88
Sodium carbonate (sal soda).....	3.7	3.7	3.8	6.5	.64	.64	.66	1.10

The insoluble part of these waters consists of carbonates of lime and magnesia, silica, and a very little sulphate of lime (gypsum); also traces of iron, alumina, and phosphoric acid.

The soluble salts exceed, in the months mentioned, what is usually deemed admissible in waters for permanent irrigation, unless special measures be taken to remove the salts from time to time. The presence of carbonate of soda should be counteracted by the use of plaster—say one hundred pounds the first year, and half that amount each succeeding year. The soil is so porous that a leaching out of accumulated salts would seem to be easy by thorough flooding in winter.

D. ARTESIAN WATERS.

Water from an artesian well on an island in the middle of Suisun Bay; sent by Mr. J. W. Dutton, Dutton's Landing, Solano County. "This water came from a depth of two hundred feet below the surface, and was pumped up with a deep-well pump through a two-inch pipe. The water in the well rises to within twenty inches of the surface. The strata passed through in this well are as follows: A heavy clay soil or slickens from eight to ten inches deep, underlaid by a half decomposed vegetable-rooty peat to a depth of seventy feet; near the bottom of the latter, mud of a bluish nature is found. To a depth of one hundred and eighty to two hundred feet there are layers of dark sand and gravel, alternating with blue clay, from seven to ten feet each; the lower strata of the latter are very firm, and sometimes nearly as hard as dry putty. In some cases we have found a yellow clay, under which the best water was had. If we go below two hundred feet the strata average about the same, with gravel somewhat coarser, to a depth of three hundred and ten to three hundred and thirty feet, where a stratum of white sandstone, or a kind of limestone, occurs, under which water is found very strongly charged with sulphur; on opening a bottle of it, after being sealed for twenty-

* Analyzed at the request and expense of the sender.

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four hours, a very decided odor of sulphuretted hydrogen gas is perceptible. Cattle drink it ravenously and seem to thrive on it well."

The sample is clear and colorless, and an examination shows it to have the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	83.82	14.35
Soluble in water after evaporation	54.32	9.30
Insoluble in water after evaporation	19.86	3.40
Organic matter and chemically combined water	9.64	1.65
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.87	.33
Sodium chloride (common salt)	45.00	7.70
Sodium carbonate (sal soda)	7.45	1.27
The insoluble part consists of—		
Calcium and magnesium carbonates Calcium sulphate (gypsum)	16.59	2.84
Silica	3.27	.56

The water is rather strongly saline, more than one half of its mineral contents consisting of common salt; it seems to be only diluted sea water. It is unfit either for domestic use or for irrigation.

Water from a flowing gas-well in Sacramento; sent by the "Sacramento Natural Gas Company."

"The well is three hundred and eighty feet deep, the following strata having been passed through:

Loam and sand	31 feet.
Bluish sand	16 feet.
Gravel and cobblestones	54 feet.
Alternating beds of clay and sand	4 feet.
Sandy cement	42 feet.
Blue clay	57 feet.
Clay and sand in streaks	71 feet.

"The last stratum was a quicksand, underlaid with a thin clay sheet, followed by coarse sand, from which came a flow rising six feet eight inches above the surface of a low lot; the diameter of the pipe is eleven inches. A large quantity of gas accompanies the water."

The sample of water is clear, with a slight odor of sulphuretted hydrogen; its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	28.91	4.96
Soluble in water after evaporation	13.72	2.35
Insoluble in water after evaporation	9.35	1.60
Organic matter and chemically combined water	5.84	1.00
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	8.99	1.54
Sodium chloride (common salt)	1.64	.28
Sodium carbonate (sal soda)	3.09	.53
The insoluble part consists of—		
Calcium and magnesium carbonates Calcium sulphate (gypsum)	4.15	.71
Silica	5.20	.89

This water differs rather markedly from the waters that usually accompany the gas around Stockton, which seem to be merely brackish waters slightly changed. Here the amount of common salt is quite

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small, while, on the other hand, it contains enough sulphate of soda (Glauber's salt) to create discomfort with some persons who use it. It belongs to the same class of carbonate of soda waters that are found southward of Merced.

The mineral contents of the water are not large, and most people would quickly become accustomed to its use.

For irrigation the water would be good enough on sandy land, or even on well-drained loam land, but on heavy soils it would gradually cause alkali to accumulate.

Water from the artesian well at the Asylum for the Insane, Stockton; sent by Dr. H. W. Rucker, Medical Superintendent. The well was bored to a depth of one thousand and seventy feet.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	47.84	8.19
Soluble in water after evaporation	33.41	5.72
Insoluble in water after evaporation	9.41	1.61
Organic matter and chemically combined water	5.02	.86
The soluble part consists of—		
Sodium and potassium sulphates	1.52	.26
Sodium chloride (common salt)	22.92	3.79
Sodium carbonate (sal soda)	8.97	1.67
The insoluble part consists of—		
Calcium carbonate	1.30	.23
Magnesium carbonate	2.51	.42
Calcium sulphate (gypsum)	.40	.07
Silica	5.20	.89

The chief mineral constituent of this water is common salt, which, though not very excessive, injures what otherwise would be a very good water for domestic use. If used for irrigation purposes it would soon render a heavy soil saline; but on a porous soil, kept well tilled, it would doubtless do well with proper precautions.

Artesian water, from the waterworks at Stockton; sent by Mr. A. M. Noble, Secretary of the San Joaquin County Board of Trade. The source of the water is a deep bored well. The water is clear, tasteless, and odorless, and has the following composition:

	Grains per Gallon.
Total	23.89
Again soluble after evaporation	11.51
Sodium carbonate (sal soda)	4.33
Sodium chloride (common salt)	3.41
Chlorine	2.07

	Parts per Million.
Free ammonia	.250
Albuminoid ammonia	.124

So far as the mineral contents are concerned they do not differ materially, either as to quality or quantity, from the ordinary well and spring waters of the Coast Range, and notably of the Santa Clara Valley. It is somewhat hard, but well within the range of good potable waters.

Considering its origin from deep bored wells, the somewhat high proportion of free and "albuminoid" ammonia forms no objection, being referable to the solvent action of carbonate of soda upon the peaty sub-

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strata of the valley; and therefore of no sanitary significance, here as elsewhere, so long as the water is not stored in large reservoirs so as to permit of the development of minute vegetable growth. Under such conditions it will be a good water for all domestic purposes.

Water from the artesian and gas well of St. Agnes Academy, Stockton; sent by Rev. W. B. O'Connor.

"The well is one thousand three hundred and fifteen feet deep, the last fifteen feet being in a bed of coarse gravel, round and smooth, as if worn by the action of a mountain stream."

The sample is clear and colorless, with a decided saline taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	174.94	29.95
Soluble in water after evaporation	135.75	23.24
Insoluble in water after evaporation	15.83	2.71
Organic matter and chemically combined water	23.36	4.00
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.), small. Sodium chloride (common salt)	132.63	22.71
Sodium carbonate (sal soda)	3.12	.53
The insoluble part consists of—		
Calcium and magnesium carbonates. Calcium sulphate (gypsum), little	10.28	1.76
Silica	5.55	.95

The mineral matter in this water is very large, and consists mostly of common salt, as is the case with most of the gas wells of this State; in fact, the composition of these waters is practically that of slightly brackish tidewater. The amount of salts in it is such that it could not be used for irrigation, save perhaps in sandy soils, well under-drained naturally. On heavy soils it would quickly render the land unfit for cultivation, since it contains quite ten times as much salt as is usually considered admissible, and over twenty times as much as the water of Mokelumne River.

Water from an artesian well on the ranch of Mr. H. T. Emeric, San Pablo, Contra Costa County. The water was obtained at a depth of one hundred and seven feet. The following strata were penetrated: Black soil, gravel, yellow clay, cement rock, and gravel; in the latter the water was found. The sample is clear and colorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	27.45	4.70
Soluble in water after evaporation	12.85	2.20
Insoluble in water after evaporation	9.93	1.70
Organic matter and chemically combined water	4.67	.80
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.25	.55
Sodium chloride (common salt)	3.41	.59
Sodium carbonate (sal soda)	6.19	1.06
The insoluble part consists of—		
Calcium and magnesium carbonates. Calcium sulphate (gypsum)	8.18	1.40
Silica	1.75	.30

The water contains a rather large amount of saline matter, but not enough to be injurious for ordinary uses. It will be a little

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"hard" from the presence of the carbonates of lime and magnesia, but these can be removed by boiling or by adding a little lime water, say one twentieth, and letting it settle. The carbonate of soda may render it a good water for acid dyspepsia, but it is not strong enough to be medicinal, properly speaking.

Water from an artesian well in Goshen, Tulare County; sent at the request of Dr. C. F. Buckley, San Francisco. The sample of water is clear, colorless, and tasteless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	9.64	1.65
Soluble in water after evaporation	5.84	1.00
Insoluble in water after evaporation	2.34	.40
Organic matter and chemically combined water	1.46	.25
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.09	.19
Sodium chloride (common salt)	.42	.07
Sodium carbonate (sal soda)	4.33	.74
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	.94	.16
Silica	1.40	.24

The water is rather remarkably pure, especially considering the alkali nature of the region where it was bored. It is very nearly like the water of Kern River—if anything, a little purer. It is good both for domestic use and for irrigation purposes. Here, as elsewhere, surface water should be strictly excluded from bored wells, as it is intensely alkaline.

Water from an artesian well at Hanford, Tulare County; sent by R. W. Musgrave.

"The water comes from a depth of one thousand one hundred and fifty feet, and has a medicinal effect on some persons. The well has been bored through an immense stratum of sand to a clay."

The water is clear and tasteless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	15.18	2.60
Soluble in water after evaporation	14.31	2.45
Insoluble in water after evaporation	.58	.10
Organic matter and chemically combined water	.29	.05
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.46	.25
Sodium chloride (common salt)	5.42	.93
Sodium carbonate (sal soda)	7.43	1.27
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	.30	.06
Silica	.28	.04

The amount of mineral matter in this water is rather small, and consists almost exclusively of alkali salts, chiefly common salt and sal soda, which, in such small quantities, are not prejudicial to its domestic use. The surface waters of the region usually differ from it in being of a much more saline and purgative character.

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Artesian water from the reservoir on Richard Gird's ranch, Chino, from which the water supply for South California Experiment Station, near Pomona, is drawn. The sample is clear, colorless, and tasteless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	11.94	2.04
Soluble in water after evaporation	3.03	.52
Insoluble in water after evaporation	7.92	1.35
Organic matter and chemically combined water	.99	.17
The soluble part consists of—		
Sodium sulphate (Glauber's salt)	1.25	.22
Potassium sulphate	1.05	.18
Sodium chloride (common salt)	.28	.04
Sodium carbonate (sal soda)	.47	.08
The insoluble part consists of—		
Calcium carbonate	4.54	.78
Magnesium carbonate	1.30	.22
Calcium sulphate (gypsum)	.53	.09
Silica	1.55	.26

This is an excellent water for both domestic use and for irrigation. At the rate of one tenth of an inch per acre it will supply about sixty-two pounds of potash sulphate annually, being more than most crops require, and worth at wholesale $1 85.

Water from an artesian well at San Bernardino; sent by Mr. W. H. Avery, Los Angeles.

"The well is one hundred and eighty feet deep, and is one of the seven similar wells located at the foot of the mountains six miles northeast of the city of San Bernardino. The temperature of the water is 84 degrees Fahrenheit. This water is used for the irrigation of citrus trees on the granite soil at the base of the mountains. It is considered unsuitable for domestic use, producing slight sickness, and not so effectually quenching the thirst as other waters."

The water is clear, colorless, and odorless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	15.77	2.70
Soluble in water after evaporation	11.56	1.98
Insoluble in water after evaporation	1.70	.29
Organic matter and chemically combined water	2.51	.43
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	5.33	.91
Magnesium sulphate (Epsom salt), small amount.		
Sodium chloride (common salt)	1.34	.23
Sodium carbonate (sal soda)	4.89	.84
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	1.40	.24
Silica	.30	.05

This water is weak in mineral matter, but the greater part of this consists of Glauber's salt and sal soda, with a little Epsom salt, which would together, doubtless, affect some persons as a mild laxative; otherwise it is suitable for all domestic uses. In view of its somewhat considerable proportion of carbonate of soda, its continued use on soils not very pervious will, after awhile, require the use of gypsum as an antidote.

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Water from an artesian well south of Santa Ana; sent by Mr. C. T. Hopkins, Pasadena, Los Angeles County. The well is in a region of moist adobe lands, whose ground-water is within a foot of the surface. The sample of water is clear, colorless, and tasteless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	24.59	4.21
Soluble in water after evaporation	11.68	2.00
Insoluble in water after evaporation	6.31	1.08
Organic matter and chemically combined water	6.60	1.13
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	7.29	1.25
Sodium chloride (common salt)	.68	.11
Sodium carbonate (sal soda)	3.71	.64
The insoluble part consists of—		
Calcium and magnesium carbonates.	5.14	.88
Calcium sulphate (gypsum), very small		
Silica	1.17	.20

The mineral matter in this water is not very large, although the Glauber's salt present might act as a slight purgative with some persons at first. For irrigation purposes it is a little stronger in alkali than is desirable upon adobe soil, though it will do upon well-drained lands. This is one of a number of wells that have been allowed to "run wild" on these coast lands for a number of years, and although not at all strongly alkaline in themselves, have converted an originally non-alkaline soil into an alkali swamp, on which it is difficult to grow anything useful. It is, of course, quite feasible to reclaim these lands by capping the wells and draining; and there ought to be regulations prohibiting the running to waste of water from artesian wells, both for the preservation of the artesian supply and for protection against such injury as has occurred here.

Water from the artesian well at Elsinore, San Diego County; sent by Mr. E. Z. Bundy.

"The well is one hundred and twenty-five feet deep and seven inches in diameter. At one hundred and twenty feet, in a gray granite, water was struck which flows forty-four gallons per minute, and has a temperature of 110 degrees Fahrenheit. The water is used for drinking and bathing purposes by one half of the citizens of Elsinore."

The sample is clear, and has a taste of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	19.28	3.30
Soluble in water after evaporation	12.85	2.20
Insoluble in water after evaporation	5.55	.95
Organic matter and chemically combined water	.88	.15
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	5.02	.86
Sodium chloride (common salt)	1.64	.28
Sodium carbonate (sal soda)	6.19	1.06
The insoluble part consists of—		
Calcium and magnesium carbonates	2.04	.35
Calcium sulphate (gypsum)		
Silica	3.51	.60

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The total mineral matter in this water is about the same as in that supplied to the city of Los Angeles from the Los Angeles River, but differs materially in kind, being not nearly so hard; *i. e.*, containing much less of lime and magnesia, but considerably more of carbonate of soda. The latter prevents the slightly purgative action that might be expected from the Glauber's salt. The water is therefore entirely unexceptional for domestic use. If used for irrigation, it would be necessary to offset the "black alkali" (carbonate of soda) that would gradually accumulate in the soil, by an occasional dressing of gypsum or land plaster.

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III. ANALYSES OF ROCKS, CLAYS, MARLS, PEAT, GYPSUM.

"*Phosphate rocks*" (two samples); sent by Mr. Samuel Cassidy, Petaluma, Sonoma County. "How much phosphoric acid is there in the samples?"

An analysis showed the presence of only eight hundredths (.08) of one per cent in one of the samples; and in the other, sixteen hundredths (.16) of one per cent. These amounts are not more than is found in ordinary soils.

Soft limestone; sent by the Germain Fruit Company of Los Angeles. "How much phosphoric acid does it contain?"

The material is chiefly carbonate of lime, with thirty-six hundredths (.36) of one per cent of phosphoric acid, and nearly three (2.98) per cent of silica. The amount of phosphoric acid is extremely small, and would not justify its use as a fertilizer. Some good soils contain nearly as much as does this limestone.

Rock and clay from near Santa Barbara; sent by Mr. J. C. Merrill, of Los Angeles, for examination, to ascertain its adaptability for the manufacture of Portland cement. "There is quite a ledge of the rock near Santa Barbara."

An examination showed that the *rock* contains very little carbonate of lime, and is chiefly an *infusorial earth*. The *clay* is simply an adobe, containing 10.88 per cent of carbonate of lime. Neither material is of value for the making of Portland cement.

"*Cement rock;*" sent by Messrs. Fraser Bros., of South Riverside. It was found to contain:

Calcium carbonate	59.99
Calcium sulphate (gypsum)	.15
Magnesium carbonate	9.79
Clay and silex (mostly the latter)	22.67
Iron and alumina	4.00
Volatile matter and chemically combined water	1.88
Total	98.48

There is too much magnesia in the rock; and an examination of the insoluble residue under the microscope shows that instead of being chiefly clay, as it should be, it is prevalently a very fine silex only. The tests made as to its setting qualities resulted very unfavorably, for there seem to be no hardening qualities whatever in the burnt mass. The material thus affords no advantages for the manufacture of Portland cement, the presence of so much magnesia alone disqualifying it from use as a cement material.

Clay and limestone from near Riverside, San Bernardino County; sent by Mr. Francis Cuttle, for examination as to their fitness for the manufacture of hydraulic cement.

The clay is greenish in color, and is slightly gritty to the teeth; softens quickly under water and becomes fairly plastic. The limestone (marble) contains a small amount of carbonate of magnesia. The composition of the air-dried clay is as follows:

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Insoluble matter	30.85	55.67
Soluble silica	24.82	
Calcium sulphate (gypsum)		3.18
Magnesia (carbonate of magnesia)		5.68
Carbonic acid (carbonate of magnesia)		6.24
Peroxide of iron		6.84
Alumina		10.14
Alkalies, etc.		2.19
Water and organic matter		10.06
Total		100.00

The clay is near the lower limit of adaptable materials, since, when calculated to the dry substance, the alumina stands within a fraction of a per cent of the Medway clay, which is used for the original Portland cement. It, however, differs in other respects, and its precise qualities cannot be predicted without a practical trial. The limestone, while rather hard to grind fine enough, is sufficiently pure, and may be used experimentally in the proportion of a little more than two to one of the clay.

Clay from near Bakersfield; sent by Mr. Geo. Johnston, San Francisco, to be examined with respect to its possible fitness for fining wines.

The clay underlies the deposit of gypsum; it has a light bluish tint, and is gritty to the teeth, due to the presence of fine sand. A decided clay odor was perceptible on boiling the sample with water; after six hours' boiling the odor practically disappeared. An examination shows the clay to contain:

Silica, sand, etc.	75.00
Lime	.50
Alumina, with some ferric oxide	24.50
	100.00

The first requirement with respect to the fining of wine is that the clay should not impart the "clay" taste to the wine. This condition is fulfilled by the sample only after six hours' lively boiling, which is a long time. Still, steam is cheap, and it might be done. Its content of one half (.50) of one per cent of lime is within the limits of the Spanish fining clays; and so are the amounts of iron and alumina. Apart from the taste, then, this clay might do for fining.

Marl ("shell lime"); sent by J. DeBarth Shorb, Esq., San Gabriel, Los Angeles County, to be examined for phosphoric acid.

The marl contains 60 per cent of carbonate of lime, and only twenty hundredths (.20) of one per cent of phosphoric acid. A conglomerate that accompanies it has the same amount of lime, and only ten hundredths (.10) of one per cent of phosphoric acid. The two samples are therefore of no value as far as regards their content of phosphoric acid. Upon soils deficient in *lime*, their application would doubtless be attended with good results.

Peat; sent by Mr. C. J. Davis, Colton, San Bernardino County.

"The deposit, or rather accumulated growth, is found on the level ground, away from any wash, and lies in a somewhat circular area with a level surface, which is about five feet above the surrounding country. Springs are yet forcing their waters up to the top of the deposit, but the flow sinks again before reaching the edges of the bank. It is at least eight feet deep. Citrus growers have for years been putting this peat in the bottom of the holes in which the young trees are planted.

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and are loud in their praise of its qualities. I think that the Colton terrace soils will be greatly benefited by it; and all soils, not adobe, upon which it has been used seem to retain moisture better for its presence; the trees are very dark green, with good growth and strong branches."

The sample is brownish black in color, and, air-dried, yields:

Organic matter, etc.	90.44
Ash	9.56
	100.00
Ammonia, ready formed	.04

The ash contains:

Soluble matter	1.70
Insoluble matter	7.86

The soluble part of the ash consists almost wholly of gypsum; the insoluble part consists chiefly of silica, with some gypsum and sand.

The fresh mass sent contains three fourths of its weight of water, and practically half of this is retained on drying, this being due to the great absorptive power of humus for moisture as well as for other gases. Of course this will, so far as it goes, render it valuable for droughty (very sandy) soils, in increasing their retentiveness. The available nitrogen (ammonia) is very small, hardly enough to be considered, as it would only amount to eight pounds in a ton of the raw material (value, about $1). Of course there is more nitrogen in the peat, but it is in the inactive form in which it exists in common humus, and of no definite value, save in the long run.

Of other useful ingredients, the important phosphates and potash compounds are present in traces only. The soluble part of the ash consists essentially of gypsum, with a little common salt, some lime, and carbonate of soda.

As a direct fertilizer, then, the material can be seriously considered, only in the case of soils very deficient in vegetable matter, such as the mesa soils around Colton and elsewhere, where the increase of retentiveness would be an important consideration. In any case it would of necessity have to be used in connection with some lime, marl, or wood ashes, to neutralize its acidity. But as a material for making composts, and for retaining the valuable liquid and gaseous portions of the manure, which are commonly lost from the manure pile, the peat would be of great usefulness. For that purpose it should be allowed to dry, and then used with other litter, as a most effectual absorbent.

Peat, from the San Bernardino Valley; sent by Mr. Wm. H. Avery, Los Angeles, to ascertain its value as a fertilizer. It is formed in "cienegas," chiefly from the roots of grasses. Its composition is as follows:

Organic matter, etc.	35.70
Ash	64.30
	100.00
Nitrogen, total	1.31

In the ash were found:

Phosphoric acid	.36
Soluble potash	.06

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There is not enough of active nitrogen, phosphoric acid, and potash in this material to make it of value as a fertilizer. On general principles the peat is valuable as an absorbent for use in stables, corrals, etc.; and, when used with lime or marl, cannot fail to work a great improvement on the mesa soils of that region in supplying humus to them. It would be of little value upon moist lands, in which humus is, as a rule, abundant. The nitrogen of peat is well known to be in a very inert condition naturally, but becomes gradually available when subjected to the action of carbonate of lime, such as marls, plastering, etc.

Gypsum; sent by the Alpine Plaster and Cement Company, Los Angeles. "The material is very slow-setting, and when mixed with sand makes a very fine wall plaster. It is not a rock, but can be shoveled like earth. It sets under water, but will not stand the effect of running water. Will it make a cement for walks in the place of Portland cement?"

An examination showed the following composition:

Calcium sulphate (gypsum)	94.6
Clay	1.3
Sand	.2
Carbonates of lime and magnesia, and moisture	3.8
	100.0

This sample is practically pure gypsum, the impurities contained in it not being such as to materially change its character as plaster. It is just possible that there may be a slight addition to the final hardening from the presence of a little clay and carbonate of lime, forming a hydraulic cement when burned together; but the presumption is that when the material is burned high enough for cement the plaster is over burned, and *vice versa*. For all practical purposes the material is plaster, pure and simple, which is soluble in water, and therefore can not be made to resist running water, unless impregnated with some water-proof material, such as asphalt; the latter, of course, can only be applied after the cast is made and dried.

Gypseous clay from near Riverside; sent by D. L. Wilbur, Esq., Riverside, to have its value as a fertilizer ascertained.

The clay contains 48.9 per cent of gypsum, and is, to that extent available for the correction of "black alkali."

Gypsum; sent by T. H. Keeney, San Francisco. "Will it answer as a fertilizer, or an antidote for alkali lands?"

The air-dried sample, on analysis, was found to have the following composition:

Sulphate of lime (gypsum)	72.1
Carbonate of lime	3.1
Sand and silica	7.9
Clay, water, etc.	16.7
	100.0

The percentage of gypsum is below the average of the samples heretofore examined from the Bakersfield deposit, which was about 85 per cent, but for all that the material will serve as good a purpose, the only difference being that a larger quantity will have to be hauled.

Numerous other samples of gypsum, calcite, and other rocks and minerals have been determined mineralogically, without analysis.

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IV. ALKALI.

ALKALI; ITS NATURE, CAUSES, AND REPRESSION.*

By E. W. Hilgard.

[It should be premised that, as stated in previous publications, no signs of alkali existed in the Fresno plateau—the divide between the San Joaquin and Kings Rivers—at the time the region was settled some sixteen years ago, nor for some time thereafter. Small spots of alkali gradually made their appearance in the older settlements, and visibly enlarged from year to year, finally causing vines and trees in the center of the spots to sicken and die. This state of things has now attracted the serious attention of the progressive inhabitants who do not intend to sell out, but to preserve a good heritage for their children or successors. It was by the request of a number of these that this lecture was prepared and delivered.]

The first point to be discussed in considering the subject I have been asked to bring before you is "*What is alkali?*"

The chemist will tell you that it consists of soluble compounds—salts—the basis of which is mainly soda, together with smaller amounts of potash, and usually a little lime and magnesia. When these salts are present in the soil to any considerable extent, their presence becomes manifest, in summer, by their appearance on the soil-surface in the form of white crusts or crystals. These represent mainly the following compounds: Sulphate of soda, or Glauber's salt, which is sometimes used as a medicine for cattle and horses; chloride of sodium, or common salt, which you know too well to require description; and last, but not least, carbonate of soda, or sal soda (washing soda), with which you are almost equally familiar. With these predominant salts, which are nearly always present in varying proportions, there are, in much smaller amounts, other salts highly important for vegetable nutrition, namely: sulphate of potash, phosphate of soda (or of lime), and very often nitrate of soda or Chile saltpeter; all ingredients of commercial fertilizers, the presence in which determines their value, and which are of prime importance to plant growth. With these we find usually to a greater or less extent Epsom salt, or sulphate of magnesia, and a little gypsum or sulphate of lime.

Next comes the question: "*How do these alkali salts get into the soils?*"

The reply is, that all soils are formed from rocks in which these substances occur in various forms, by the combined chemical action of air and water, and by mechanical pulverization by frost, flowing water, and moving ice, or glaciers. The same alkali salts are formed everywhere in the world; but in countries having abundant rainfall they are currently washed, as formed, into the country drainage, while in regions where rainfall is deficient, the scanty moisture only carries them a little way down into the subsoil, from which they rise to the surface by the evaporation of the water, and are thus accumulated at, and close to, the

* Synopsis of a lecture given at the Farmers Institute held at Fresno, April 3, 1891.

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very top of the soil. It is right there that nearly all the damage is done; the water in the depths of the soil is very rarely strong enough to hurt the roots of plants, directly.

It follows from what I have said that "*all natural waters must contain alkali salts*" *to a greater or less degree.* That this is actually so can be seen from the table below, which shows the composition of a number of rivers in your valley and elsewhere, by giving, in grains per gallon, the amount of each of the salts present. Taking into consideration, for our purpose, only the soda and potash compounds here shown, it is seen that the purest water, from this point of view, is that of the Mokelumne; next in purity comes that of Kings River, which runs in your ditches; the largest amount of alkali is shown by the water of Kern River. It is the evaporation, for countless ages, of the Kern River water that has filled the lake basins of the upper San Joaquin Valley with waters now so strong in alkali that to use them for irrigation would be to quickly fill the lands on which they are used, with more alkali than would be compatible with crop-bearing.

ANALYSES OF WATERS FROM THE SAN JOAQUIN VALLEY.

Grains per Gallon.

	Total Residue.	Carbonate of Soda.	Common and Glauber's Salt, etc.	Carbonates of Lime, Magnesia, and Silica.	Vegetable Matter.
1. Los Angeles River	17.53	.....	8.37	9.16	.....
2. Kern River (cañon)	9.49	1.22	1.77	5.55	0.95
3. Kern River (ditch)	9.62	1.23	2.21	5.83	0.85
4. Kern Lake	211.50	64.37	115.41	9.29	22.43
5. Tulare Lake (south end)	84.44	27.92	37.85	13.44	2.23
6. Tulare Lake (middle, surface)	81.95	35.30	35.96	5.37	5.32
7. Tulare Lake (middle, 10 feet below surface)	81.83	30.46	39.49	7.47	4.41
8. Tulare Lake (middle, 20 feet below surface)	81.72	.....	.....	.....	.....
9. Tulare Lake (near mouth of Kings River)	38.55	13.46	15.01	5.11	4.97
10. Tulare Lake (near outlet of west side canal, 10 feet below surface)	76.00	30.95	33.95	6.60	4.50
11. Kings River (June)	4.13	0.00	0.86	3.27	.....
12. Kings River (November)	5.03	.....	.....	.....	0.19
13. San Joaquin River	4.54	0.45	0.15	2.15	0.89
14. Merced River	5.64	0.19	0.09	4.18	.....
15. Mokelumne River	6.97	.....	0.42	4.42	3.70
16. Sacramento River	6.69	0.27	1.42	5.00	.....
17. Point of Timber (San Joaquin delta), well water	67.75	10.83	48.41	7.41	1.10

"*How and why does alkali rise to the surface?*" As I have already said, it is surface evaporation that brings it up. The soil acts like a wick; and if you will take a lamp wick and plunge its lower end in salt water, while exposing the upper end to the air, you will quickly see an "alkali crust" forming on that end.

But you also know that different wicks will raise water or coal oil to different heights, according as they are closely woven or loose like candle-wicking. The close wick will raise the fluid higher, but it will rise to its highest point more slowly than when you use the loose wicking. Just so in soils—the close ones will raise the soil water from a greater depth than loose sandy soils, but the latter will bring it up much quicker to the full height to which it can rise at all.

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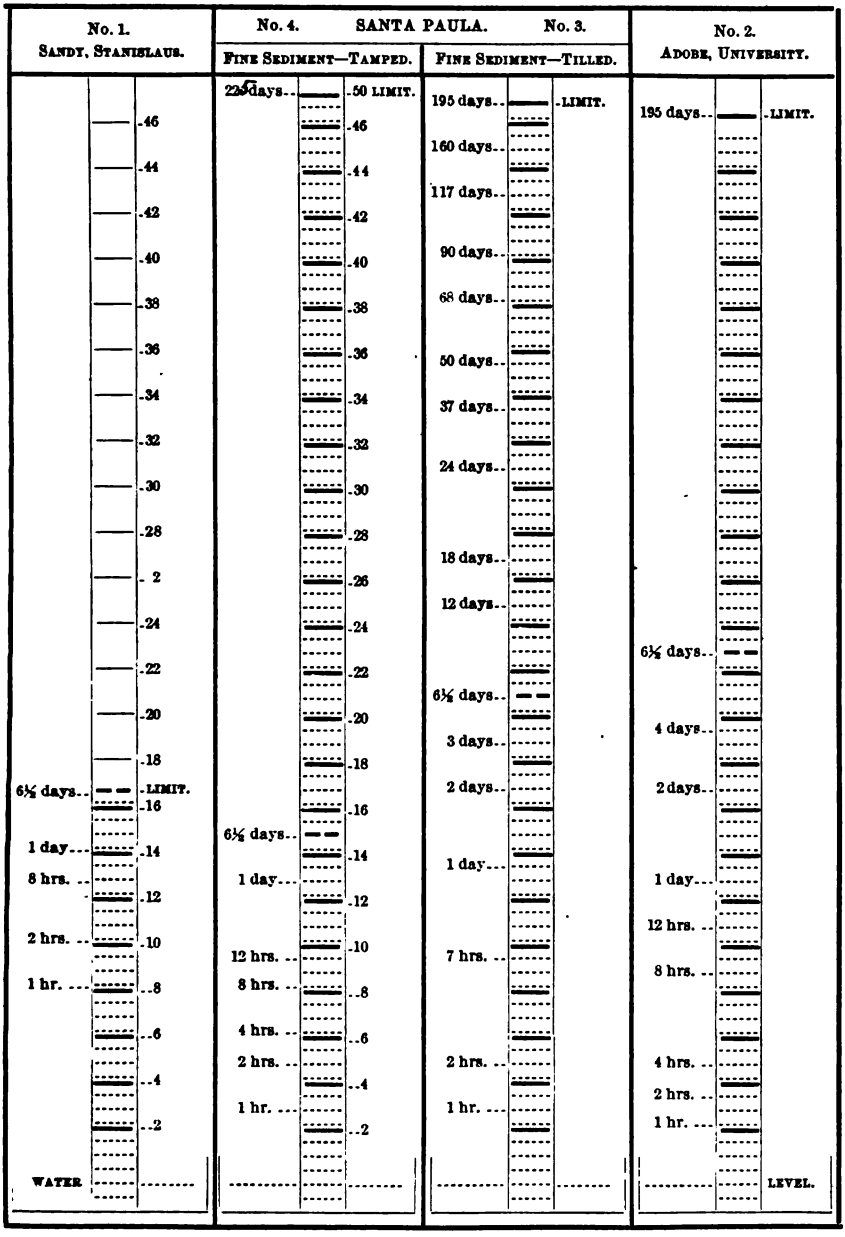
TABLE

Showing Rapidity of Ascent of Water in Different Soils, and Limit of Same.



The diagram before you shows these differences. The coarse sandy soil from Stanislaus has, in six and a half days, sucked up the water to the full height of sixteen and a half inches, and has remained there. Within the same time the close adobe soil of our experimental grounds

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at Berkeley has made the water rise to the twenty-three-inch mark, but it has taken it nearly two hundred days to reach the final maximum height of forty-six inches; and there are some soils in which water will, in the end, rise even higher—say to fully five feet.

You see, then, that if alkali water should stand in a sandy soil at the depth of two feet, very little of it would evaporate at the surface, and therefore alkali would show on the surface only slightly, or not at all; while from a clay soil having water even twice the depth, the evaporation from the surface would be brisk and continuous, and an alkali crust would promptly form. You know well from your experience that alkali is always worse on clay soils than on adjacent sandy ones.

Beyond question *the damage done by alkali (in at least nine cases out of ten) is due to accumulation at or near the surface.* When we examine the soil of an alkali spot for its alkali contents at various depths, we find five or six times as much in the first inch from the surface down as is contained in the bottom water, or at the depth of a few feet in the soil itself. The top crust is sometimes almost pure alkali salt, and it is no wonder that it should corrode the stem or root-crown, and weaken or kill the plant. It obviously follows that the first requirement in preventing damage from alkali, is to prevent surface evaporation as much as possible. The first condition in this regard is to lessen the formation of a surface crust; in other words, to keep the soil in deep, loose tilth, or else, to mulch it. In either case, surface evaporation is reduced to the lowest point practically attainable. Evaporation through the leaves of plants—for instance in an alfalfa field—brings up no alkali to hurt. *More than half of the alkali land in this State that people are afraid to touch, requires no other remedy than thorough, deep tillage, maintained at all times.*

But in bad cases other means are required; and this leads us to consider *which of the above salts is the most injurious.*

Your experience tells you that the worst alkali is the "black." Now what is black alkali, and why is it so called?

Not, as some have imagined, because of its moral turpitude, but because it causes blackish tinted puddles to stand on the ground, and on evaporation, leaves black rings around the margin of the pool. When we analyze such blackish water we find that its chief ingredient is carbonate of soda—sal soda—and that the black tint is caused by the humus of the soil, which it has the power to dissolve. This in itself is a serious injury, for humus is one of the most important of soil ingredients. If held in solution, or washed away *through* the soil, the producing powers of the land are seriously impaired.

That, however, is not the end of the injury; for when accumulated by evaporation around the root-crown, it absolutely corrodes and dissolves the bark as it does the humus of the soil, causing a dead ring around the butt, and finally girdling the stem as effectually as could be done by the knife; or, even worse, because the wound is poisoned and the wood attacked after the bark is gone.

Nor does the injury end there. In heavy (adobe) soils the presence of a small amount of sal soda renders tillage almost impossible; in all cases it renders the production of good tilth more difficult, causing the formation of little close-textured pellets instead of true tilth. I will illustrate these points to you by experiment.

Here is a calcareous "adobe" soil wetted with pure water and dried

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I throw it on the floor before you, and it crumbles into a thousand crumbs. Here is a lump of the same soil wetted with sal soda solution, and also dried; I throw it on the floor and you hear it strike like a brick-bat, and it breaks into two or three hard clods, which you can just scratch with your finger nail.

You see the extreme importance of getting rid of the "black" part of alkali in every case. *This can be done by giving the soil a dressing of gypsum or land plaster.*

Here is a solution of sal soda; I pass it through this filter filled with black soil; you see the water that passes through is almost as black as ink, and we now have the same solution that you see in alkali puddles where it is "black." Had I time to finish this operation you would in the end find the black soil turned gray or whitish, just as are your alkali spots after the rain has washed out the color.

Now, I add to this black water a quantity of powdered gypsum, and shake it up. We shall have to wait a little to see the action completed; but in the end you will see that the solution has become nearly or quite colorless, while the gypsum has turned dark from the precipitated humus. That is precisely the way it acts in the soil; it keeps the humus from being washed away, and above all, it converts the "black" alkali into "white;" that is, the carbonate of soda has now been turned into sulphate of soda or Glauber's salt, which, as I first told you, is one of the chief ingredients of all our alkali, and is quite bland and harmless as compared with the corrosive sal soda. We have thus taken the cutting edge off the alkali.

In thousands of cases this change, with thorough tillage, is all that is needful to do away with all damage from alkali. The amount of plaster to be used per acre depends, of course, upon the strength of the salts in the soil. Sometimes five hundred pounds per acre will be enough, then again, it may take a ton, or even more, and after that perhaps an annual dose of from one to three hundred pounds per acre, until the carbonate of soda is completely destroyed.

You may ask how you are to know that by an easy test; here it is: This is paper tinted with a solution of litmus, a preparation you can find in most drug stores, and if not, they should be made to keep it for you; any acid (vinegar will do), you see, turns the blue solution red; add sal soda or potashes (ash lye) to the red solution, and the smallest amount will instantly turn it blue. So with this paper; as you see, I can change the color at will, and when the red paper turns blue when I touch the alkali water or the wetted soil, I know at once that there is black alkali there, even if it be too little to show in the mud puddles. Any child can make this test, but you must understand that the change to blue should be prompt. Almost any California soil will, in the long run, turn litmus paper blue, because all contain considerable lime, which acts like the sal soda, but much more slowly.

There is one virtue possessed by gypsum that I have not yet alluded to; it is, that when (as is frequently the case) the alkali contains phosphates in solution, these phosphates are fixed and retained in the soil; whereas, otherwise, every rain and every irrigation washes them out, more or less.

But if, after transforming your black alkali into white and practicing thorough tillage, you still find your trees or vines under stress, there is

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but one remedy, a radical one, which rids you of all alkali, black and white, for good—*that remedy is* UNDERDRAINAGE.

That this is so is self-evident from the fact that in countries having heavy rainfall there is no alkali in the soils. What prevents it is the natural seepage through the soil into the country drainage. Where this does not exist naturally, it can be established artificially by first laying drain tiles and flooding the land until the last vestige of alkali is washed out. Experience fully and amply confirms this conclusion; but experience has also abundantly shown that alkali cannot be washed off the land by abundant flooding *without* drainage. All you do in that case is to put the salts down into the subsoil, from which they will rise again at the first chance, and your water and trouble will have been wasted. What you sometimes can effectively do, in bad cases, is to scrape off the alkali crust bodily and haul it off where it will be carried off by the streams—or possibly by the ditches—for the benefit of your neighbor below. Such things have happened.

But some will say, underdraining costs too much. About that I have only to say that I agree with you so long as you pay the railroad "all the traffic will bear" for freight on tiles. When you get to making your tiles right here, $35 per acre ought to pay for good underdraining in your porous soils. If there are those who think that also too much, let them cease to value their producing lands at $1,000 per acre, and sell out to progressive newcomers, who think otherwise.

It is true that the condition of things in your region is peculiar and different from most other localities in the State. Ten years ago no alkali was to be found within a long distance of Fresno City, but since that time leaky ditches have filled the country up with water from below, and that water has brought with it the soluble salts that had accumulated for ages in the forty or fifty feet of dry soil that then used to lie under your feet. As that water evaporates at the present surface, all that alkali must come to the top, unless carried off in some way, as by drainage.

I have lately, with the aid of two of your public-spirited citizens, Miss L. E. Hatch and Mr. John S. Dore, obtained the materials for a proper study of the actual state of things under your soil. They supplied me with samples of bottom water taken at various points, and by analyzing these and comparing them with the water of your ditches, we can see just how far the process of leaching upward is likely to supply your soils with alkali.

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Partial Analyses of Some Bottom Waters of Fresno Region (grains per gallon).

	June, 1880.	Aug., 1889.	February, 1891.						
	No. 1. Kings River.	No. 2. I. F. Mouton, 4 miles S.W. of Fresno. 6 feet.	No. 3. Ball's Vineyard. 8 feet.	No. 4. Central Col'y Hedgerow Vineyard. 7½ feet.	No. 5. Central Colony, Lot 94. 7 feet.	No. 6. Jas. Hughes' Place. 8 feet.	No. 7. Washington Colony (Pond). 3 feet.	No. 8. Unused Well, 1 mile W. of West Park. 5 feet.	No. 9. J. S. Dore's Vineyard, West Park. 5½ feet.
Sodium and potassium sulphates (Glauber's salt, etc.)	.86	60.6	1.2	3.5	2.7	4.5	33.7	1.9	12.7
Sodium chloride (common salt)			1.0	.5	1.4	.5	24.5	1.4	.7
Sodium carbonate (sal soda)	.003	12.4	3.7	1.9	21.1	4.3	39.7	5.6	6.2
Calcium and magnesium carbonates, calcium phosphate, etc.	3.27	3.9	5.3	8.5	6.0	8.8	6.5	3.7	5.8
Silica		3.0	7.6	3.9	3.5	3.8	.3	2.5	2.3
Organic matter and chemically combined water		4.7	4.1	6.8	2.9	4.6	13.0	4.2	4.7
Totals	4.133	84.6	22.9	25.1	37.6	26.5	117.7	19.3	32.4

No. 7—In Detail.

Potassium sulphate	8.0
Sodium sulphate	25.7
Sodium nitrate	Traces.
Sodium chloride	24.5
Sodium carbonate	39.7
Calcium phosphate	.8
Calcium carbonate	4.2
Calcium sulphate	Traces.
Magnesium carbonate	1.5
Silica	.3
Organic matter	13.0
Total	117.7

No. 2—Increase of Alkali from Bottom Water to Surface.

Depth.	Alkali in 100 Parts Soil.
Surface, 1 inch	0.76
18 inches	0.20
26 inches	0.18
42 inches (hardpan)	0.16
72 inches (bottom water)	*0.145

*84.6 grains per gallon.

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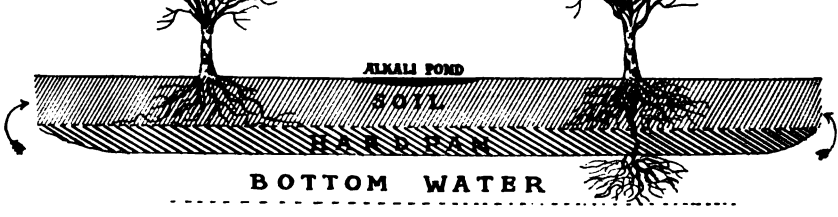
Let me say from the outset that the results of this investigation (which I place before you) have been most encouraging. While it is true that there has been a serious increase of alkali over the Kings River water in all cases—say from seven to ten times, so far as the true alkali salts are concerned—yet the water, even thus, is not worse than a good deal that is used elsewhere for irrigation. There are two very bad cases, as you see, in which the alkali salts have increased from eighty to over a hundred times, forming dangerous waters. But these are taken from ready-formed alkali spots of an aggravated type; and for the existence of these there is a special cause to which you must pay the closest attention.

This cause is the existence, at various depths beneath the surface, of a layer of limy hardpan, which all of you have seen at some time. This hardpan is practically impervious to water, as it is to roots; your older residents know that they have many a time been obliged to "knock the bottom out" of a hole in which a tree or vine was to be planted, in order that the roots might be enabled to reach a proper depth. The sudden "going back" of plantations of trees and vines, that have been doing well the first two years, has almost invariably been traced to the existence of this hardpan, upon which the roots were compelled to spread out, or dry out, or be drowned out, according to circumstances. And *it is upon the areas underlaid by this hardpan that strong alkali has appeared in the Fresno region.*



At first sight this may seem difficult to understand, but the matter is really simple enough. In winter, when heavy rains prevail, or when the land is copiously irrigated, the bottom water rises and mixes with the irrigation water coming from above. Suppose this happens where there is a sheet of hardpan; then the mixed waters will rise around the edge of the sheet and spread over it. Now these sheets are usually basin shaped, ranging in outline from round to long-oval, and lowest in the center, with areas varying from a fraction of one acre to several acres. The water flowing in over the outer edge is retained there. It quickly evaporates from the shallow soil overlying the hardpan, and its alkali also remains and accumulates near the surface. Let this process be repeated for a few years, and several times each year, and soon the alkali accumulation will become sufficiently strong to affect the growing plants. After awhile the soil in the low center of the sheet becomes alkali-sodden, it loses tilth, and sinks down; then the alkali water gathers there, and we have formed an alkali pond like the one represented in the diagram, and by No. 7 of the table, with water too strong

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for any useful vegetation. You see it is a bad case of "black" alkali, nearly one third of the whole solids of the water being sal soda. Even here gypsum would be useful, and should be used over the entire tract affected; but nothing short of drainage, or breaking up of the hardpan sheet, can work a radical cure.

The diagram also illustrates the difference in the development of the root-system of a tree, before and after the hardpan sheet is broken. The former will be suffering from both drought and alkali; the other will flourish.

It is not ordinarily, then, the alkaline bottom water, but the local sheets of hardpan that cause the scattered alkali spots of your region, and are the real cause of what trouble there is at present. You have not to fear a sudden general overrunning of your beautiful vineyards with alkali, so long as you keep the bottom water out of reach of the surface evaporation, and thoroughly till the soil. Yet certainly, the problem of general drainage is one that should receive your immediate attention, for your plantations are too valuable to be exposed to a gradual deterioration from neglect of leaky or leachy ditches. A good example of wise precaution in this regard has been given, for instance, by the seven-foot ditch that has been drawn around the property of the Fresno Vineyard Company; that vineyard will have no need to fear alkali or swamping.

A general system of drainage will, of course, involve some perplexing questions, not the least among which is the slight fall of the Fresno plateau in any one direction. Long main drains may be needed, and so long as these are not established, many will be perplexed as to where they can discharge the alkali water. Let me suggest that local relief may be found in draining into wells, the deeper the better. This would increase the alkalinity of the general bottom water for a time, but would give present relief to many.

My time and yours is too short to go further into the details of this drainage question, so I will conclude by summing up the measures of relief I have suggested:

First of all, wherever alkali appears, *look for the hardpan*, and if found break it up at as many points as possible, so as to allow the roots and water to penetrate beneath. Be careful of thorough tillage, and never allow a surface crust to remain after rain or irrigation. If the alkali is "black," use a proper dose of plaster to make it "white." Tighten ditches to prevent the rise of alkali water from below as much as possible, and seek to drain off the latter into the country drainage, whether by underdrains or, temporarily, by open ditches, laid deep enough to keep the water from being drawn to the surface by wick action.

Some—chiefly outsiders and newcomers—ask why we should bother with alkali soils at all, so long as there is so much good soil left that is not so tainted. The reply is, that alkali soils are, from their very nature, necessarily *rich* soils, and that the labor and expense bestowed upon their cultivation under proper conditions is sure to be richly repaid by the outcome. Such soils are largely without the need of fertilization, at least for a long time to come. Look even at the water of the "alkali pond" on the table, No. 7; there is among its ingredients no less than eight grains per gallon of potash sulphate, a most valuable fertilizer, the presence of which will almost forever relieve the cultivator from the necessity of purchasing it. The alkali of the spots at the Tulare station

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would be worth about $7 per ton as a commercial fertilizer, and contains an abundance of almost every element of plant-food. It is the *excess* of useless salts that we must do away with; but we should carefully preserve and appreciate the good things nature has so abundantly supplied to our alkali soils.

ANALYSES OF ALKALI.

Alkali from soils on the farm of Sol. Runyon, near the Sacramento River, twenty miles below Sacramento; sent by N. W. Motheral, Entomologist of the State Board of Horticulture.

"*No. 1* was taken from the surface, at the root of a dying tree. *No. 2* was taken from under the tree, thirty inches from the surface, after the tree was dug up. Is there anything in the soil that would kill the tree?"

The result of the examination was as follows:

Soil No. 1.—The soluble salts in one hundred parts of the soil amount to .124 parts, and consist chiefly of carbonate of soda, with a small amount of common salt and Glauber's salt.

Soil No. 2.—The soluble salts in one hundred parts of the soil amount to .14 parts, and consist chiefly of carbonate of soda, with a considerable quantity of common salt and a trace of Glauber's salt.

The amounts of alkali salts in this soil and subsoil, as shown by analysis, are not sufficient to account for serious damage to the trees *unless permitted to accumulate on the surface by evaporation*, by neglect of deep tillage. The quality of the alkali salts is quite corrosive, and in any case, it would be best to correct this by the use of gypsum, transforming the "black" alkali into "white," or neutral salts.

Alkali from soils near Fresno; sent by Mr. J. S. Dore, Fresno.

"*No. 1* was taken from the top crust under some dead apricot trees. *No. 2* from the same soil, but eight inches below the surface. The calcareous hardpan is here just four feet below the surface. This place some ten acres in extent, has never been irrigated; it is, however, subirrigated, and the ground-water is probably nine feet below. Grape vines and fruit trees are greatly injured by these salts."

No. 1 is a silty soil with a small amount of clay, and a large number of mica scales intermixed. A water extract gave a very faint alkaline reaction and contained 6.3 per cent of salts. Of the latter, a small proportion was insoluble in water, and consisted mainly of carbonate of magnesia with a small amount of sulphate of lime, or gypsum. The part soluble in water consists mainly of sulphate of soda (and some potash), common salt, and a little sulphate of magnesia.

No. 2. This is a light yellowish sandy soil, containing many mica scales. A water extract gave .19 per cent of soluble salts, which consist largely of common salt and Glauber's salt, with considerable sulphate of potash and slight amounts of lime and magnesia.

The character of the above salts is that of "white," or neutral alkali salts, and but for the existence of the hardpan beneath would hardly be fatal to apricot trees or vines. The hardpan, however, has doubtless caused them to accumulate to such extent that, in connection with water stagnating on it in winter, the joint effect has been hurtful. The breaking up or underdraining of the hardpan, together with deep and thorough tillage at all times, would be the proper means of reclamation.

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No. 2 is but lightly charged, and with thorough tillage should not experience serious trouble from the neutral alkali salts indicated by the analysis, especially if not underlaid by hardpan.

Alkali from Pleasant Valley; sent by Mrs. M. E. Cleary, Coalinga, Fresno County. A whitish powder, accumulating by the evaporation of the waters of the streams of the valley.

The sample consists chiefly of sulphate of soda, or Glauber's salt, with small amounts of carbonate of soda (sal soda) and common salt. The waters of the streams (as is shown elsewhere) contain 119 grains per gallon of this salt, and are thus rendered unfit for domestic use.

Alkali from soil No. 1223 taken at various depths, on Sec. 3, T. 26, R. 23 E., Kern County; sent by Mr. John S. Hittell, San Francisco. It consists mainly of Glauber's salt with some common salt; no carbonate of soda.

	Depth 2 to 4 Feet.	Depth 10 Feet.
Total soluble salts in 100 parts of soil	.71	.84
Sodium chloride in 100 parts of soil	.18	.12
Sodium chloride in 100 parts of soluble extract	25.13	36.12

This, again, is neutral "white" alkali, of which only a large amount, accumulated at the surface, will injure trees or vines. This kind of alkali seems to be almost universally prevalent, where any at all exists, in the region southeast from Tulare Lake, in Kern County; doubtless owing to the fact, shown in other samples received from the same region, that crystals of gypsum are found imbedded in the subsoil at various depths, and thus prevent the formation of "black" alkali altogether. It is an excellent demonstration of the efficiency of gypsum in this respect.

Alkali from Kern Island; sent by Mr. Willis Carter, Bakersfield, Kern County. A surface crust heavily charged with soluble salts, from the effects of surface evaporation.

	In 100 Parts of Alkali.
Potassium sulphate	9.52
Sodium sulphate (Glauber's salt)	82.96
Sodium chloride (common salt)	.48
Sodium carbonate (sal soda)	.40
Magnesium sulphate (Epsom salt)	.50
Magnesium carbonate	.13
Calcium phosphate	.20
Calcium sulphate (gypsum)	.10
Oxide of iron and alumina	.30
Silica	1.34
Organic matter and chemically combined water	4.07
Total	100.00

This sample is thus seen to consist almost entirely of the sulphates of soda and potash, chiefly the former. There is not a sufficient amount of carbonate of soda to render the salts injurious to the soil, under proper conditions of subsoil and tillage. The percentage of potash is so large that the salt might be utilized as a fertilizer upon

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lands deficient in that element of plant-food. The presence of pho phates also adds to the value of the salts as a direct fertilizer.

Alkali (two samples) from the Kern County artesian belt; sent by M Geo. A. Raymond, San Francisco.

One of the samples consists almost entirely of Glauber's salt; it co tains no carbonate of soda, and only a very small quantity of sodiu chloride, or common salt. It is, therefore, of a mild type, and bei readily soluble in water, can, by proper drainage, be easily remov from the soil if found to cause damage.

The other sample is in the form of small grayish lumps, and also co sists mainly of sulphate of soda, a small amount of chloride of sodium, common salt, being also present. It is of the same mild, or "white type as the first, and, with good cultivation, should cause no seriou injury.

Alkali, extracted from a soil, from Sec. 3, T. 31 S., R. 27 E., near Baker field, Kern County; sent by Mr. S. W. Austin, San José. The comp sition of the extract is as follows:

	Soluble Salts in 100 Parts of Soil.	Composit in 100 Par of Alkali
Sodium sulphate (Glauber's salt) } Sodium chloride (common salt) }	.215	97.
Sodium carbonate (sal soda)	.005	2.
Totals	.220	100.

The presence of so small an amount of carbonate of soda does n materially injure the soil, and the other salts may not injure veget tion—especially trees or vines—so long as they are not allowed accumulate at the surface, which can, of course, be prevented by dee and thorough tillage.

Alkali crust from Colton Avenue, near Hunt's Lane, Santa Ana botto San Bernardino County; top crust of the soil.

The alkali amounts to 9.593 per cent of the crust, and consists of—

Organic matter and water	4.8
Soluble in water	93.6
Insoluble in water	1.6
Silica	.0
	100.0
The soluble portion of the alkali consists of—	
Sulphate of potash	4.8
Sulphate of soda (Glauber's salt)	62.7
Sulphate of magnesia (Epsom salt)	.5
Carbonate of soda (sal soda)	14.8
Chloride of sodium (common salt)	10.7
	93.9
The insoluble portion of the alkali consists of—	
Sulphate of lime (gypsum)	.1
Carbonate of lime	.4
Carbonate of magnesia	.6
Peroxide of iron (as carbonate of iron)	.4
Total	1.6

The amounts of soluble sulphates and of common salt in the abo crust are extremely large, and of course destructive to vegetation, b being easily soluble in water they can be readily removed by prop

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drainage. But the presence of so large an amount of carbonate of soda (nearly 15 per cent of the salt, or 1.4 parts per hundred of the soil) makes the matter a far more serious one, especially when it is remembered that a percentage of less than one tenth of one per cent is sufficient to injure vegetation, by rendering the soil caustic and corrosive, and by dissolving out the humus. The only antidote would be a large application of gypsum and the thorough drainage of the land.

Alkali from the soil of a vineyard in El Cajon, San Diego County; sent by C. M. Johnson, M.D., San Diego.

"This land has been planted in vines for five years. In the locality from which the sample No. 1 was taken the vines have all been killed, and the surface has an efflorescent, ashy appearance. Sample No. 2 was taken from an adobe soil, but little distant from the first, and on which were vines of the same age. On both of these localities there is a slight depression, and back of them is a range of foothills three hundred feet in height, whose soil is springy, giving good sub-irrigation with a water that is sweet and not at all alkaline. Olives seem to do well, and quinces are growing luxuriantly in the strongest alkaline spots."

The samples sent are understood to represent the surface crust, say to the depth of one inch. Sample No. 3 is the subsoil of the above soils.

In 100 Parts of the Soil.	Soil No. 1.	Soil No. 2.	Subsoil No. 3.
Carbonate of soda	.662	.027	.050
Other soluble salts	3.433	18.823	.482
Total alkali	4.095	18.850	.532

The chief ingredient in each of the above is sodium chloride (common salt), with large amounts of sodium sulphate (Glauber's salt). With the amount of carbonate of soda shown in No 1, these constitute a pretty bad case of "black alkali." It is therefore one of the cases in which the use of gypsum (land plaster) is indicated, and in unstinted quantity, probably not less than five hundred pounds per acre for the first dressing. Soil No. 2 is heavily charged with "white alkali," and will therefore be little benefited by gypsum. With good tillage these neutral salts might not harm the vines. The subsoil, while not very strongly charged, still shows enough to render measures for drainage advisable as soon as possible.

Deposit in boilers, obtained by boiling an earth with water; sent by P. P. Keough, Bishop, Inyo County. "Does it contain borax?"

The deposit is soluble in water, and consists chiefly of sulphates of potash and soda, the latter (Glauber's salt) predominating, considerable common salt, and a very small amount of sulphate of magnesia (Epsom salt). Borax is present only in traces.

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FURTHER EXPERIMENTS ON THE REACTIONS BETWEEN ALKALI SULPHATES, CALCIC CARBONATE, AND FREE CARBONIC ACID.*

By M. E. JAFFA.

[It will be remembered that at the meeting of this association held two years ago, I communicated a paper containing the results of a joint investigation by A. H. Weber and myself, on the formation of alkali carbonates from the sulphates, in presence of calcic carbonate and free carbonic acid. The wide importance of this reaction in nature, and practically in connection with the question of "alkali" lands and their reclamation, rendered a further pursuit of the investigation desirable, but lack of time has prevented its being carried to the extent contemplated, even in respect to the calcic carbonate alone, and only under ordinary conditions of temperature and pressure. Still, the results thus far obtained by Mr. Jaffa are of sufficient importance to render their communication at this time of interest.

The conditions under which Weber's experiments were made are given in the following quotation from the paper above referred to:

"The bulk of solution used was, in all cases, one liter; in this, precipitated calcic carbonate was kept in suspension by constant agitation while carbonic gas was being passed into it at a temperature of about 18 degrees C., usually for forty minutes. The first effect was always a slight reddening of the litmus, due to the carbonic acid; but generally this reaction changed to alkaline during the first ten minutes, becoming stronger as time progressed. But comparative experiments showed that nothing was gained in alkalinity by a longer passage of the gas than above indicated.†

"In each experiment 100 ccm. were decanted immediately after the clearing of the magma, and titrated for 'total alkalinity,' including the calcic carbonate remaining in solution. When an alkaline sulphate was employed, the undissolved carbonate was tested for sulphuric acid, which in all cases was found to be present.

"Another portion of the decanted solution was evaporated to dryness and the residue weighed as a whole, after drying at 110 degrees C., afterward leached and the filtrate titrated for its alkalinity.

"Another portion was mixed with alcohol so as to carry its percentage to about 60 per cent. This caused a gelatinous precipitate, which, after twelve hours standing, condensed into easily recognizable crystals of gypsum and calcic carbonate. The filtrate from this deposit was also titrated for its alkalinity. The subjoining table summarizes these results

* Read before the Society for the Promotion of Agricultural Science at the Indianapolis meeting, August 19, 1890. See Station Report on Waters, 1889, p. 51.

† Mr. Weber's record shows the following observations on this point:

Time.	10 min.	30 min.	60 min.	11 hrs.	12 hrs
Alkalinity in ccm. normal standard sulphuric acid	7.30	8.25	8.60	9.00	9.0

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Experiments with Potassic Sulphate.

Grams per Liter:	¼	½	1	2
Evaporation residue 110 degrees, per liter (grams)	.837	1.195	1.619	2.735
Residuary alkalinity in same (ccm. standard H_2SO_4)	.35	.50	.45	.75
Total alkalinity of decanted solution	9.95	14.10	12.25	14.10
Residuary alkalinity after precipitation with alcohol	2.875	5.75	9.70	12.90
Corresponding $HKCO_3$ (per cent of total possible)	100.	100.	83.6	55.6

"The table shows that up to one half gram per liter, and beyond to a point not yet ascertained, there is a complete decomposition of the potassic sulphate, resulting in the formation of gypsum and potassic bi-(hydro-) carbonate. In a solution containing a gram of the sulphate per liter, only 83.6 per cent of the total possible amount of the carbonate is formed, and in a solution of double that strength (two grams per liter) only 55.6 per cent. But up to that point, and evidently some distance beyond, the *absolute* amount of alkaline carbonate is still on the increase; its ultimate limit remains to be ascertained."

Following the lines pursued in the previous investigation, Mr. Jaffa has used essentially the same methods, and in part the same materials employed by Mr. Weber; more particularly in his first set of experiments, the same precipitated calcic carbonate. It will be noted that in Weber's table there is a striking discrepancy in the "total alkalinity" for the operation with five grams per liter; this discrepancy disappeared upon a repetition of the determination by Jaffa, which gave 10.15 in place of 14.10 of Weber's table, and thus brings about a reasonable regularity of progression with increasing density of the original solution.—E. W. H.]

Table No. 1 summarizes the first series of my work, in which the intention was to complete the data given in Weber's table upon potassic sulphate. Adopting the first two columns, relating to solutions of .25 and .50 grams per liter (except that the "total alkalinity" was redetermined, as above stated), all the other determinations are my own, and, as will be seen, they differ not immaterially from those of Weber's table, being higher throughout. The most striking difference is, that whereas Weber found the critical point from which the decomposition of the potassic sulphate ceases to be complete, to lie between .5 and 1.0 gram per liter, I find it to be just beyond 1.0 gram; and I find a higher percentage of decomposition with 1.25 than Weber did with 1.0 gram (90.85 per cent against Weber's 83.6 per cent of the possible amount). The cause of these discrepancies is, doubtless, to be sought for in use of different materials and in slightly different external conditions, as noted in Table No. 1.

Having exhausted the supply of the calcic carbonate used by Weber, I prepared another batch, this time by precipitation with ammonium carbonate at the ordinary temperature instead of hot, as was done by Weber; the precipitate being thus, of course, finer and more bulky, and keing kept in suspension more easily. But, at the same time, the solution required to be filtered from the precipitate of gypsum and unaltered carbonate, instead of being decanted, as was done by Weber. As the filtration of 100 ccm. lasted less than one minute, the loss of CO_2 was too slight to cause the precipitation of calcic carbonate, for usually no scum formed on the surface of the covered solution for twelve hours.

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Table No. 2 shows the results obtained with this new preparation o calcic carbonate.

It will be seen, on comparing Tables Nos. 1 and 2, that there is a wid discrepancy between the figures obtained with the first and coarser- grained calcic carbonate, and the fine powder of recent preparation While in the first case the range between .25 and 4 grams per liter i 9.95* and 14.80, respectively, for total alkalinity, in the second case th range between the same limits is from 17.76 to 23.70. The "residuary alkalinity," after precipitation with alcohol (*i. e.*, that indicating th amount of alkali carbonate formed), is, of course, the same *within th limits of complete decomposition*, in both series; and the determinatio lying just beyond (for 1.25 grams per liter) shows practically identica figures (13.06 and 13.10). But beyond that point there is a rapi increase, which is particularly noteworthy in the figures showing th *actual amounts* of bicarbonate formed. Thus we find that in the 4-gra solution, 1.42 grams of the latter salt was formed when the coarse prep aration was used, while 2.32 grams resulted under the influence of th fine precipitate of calcic carbonate, under identical conditions as t temperature and time. Moreover, in both series the progressive *increas* of the amount transformed became very slow with the 4-gram solutio the difference between the amount corresponding to 4 and 8 grams, bein (in the second series) only .15, while between the solutions containin respectively, 1.50 and 1.75 grams, the difference (for only a *fourth of gram*) is .24. It would thus seem that, *under ordinary conditions temperature and pressure*, the practical limit of action is nearly reache with a 4-gram solution.

The influence of *temperature* is rendered very apparent by the inspe tion of the entries showing the "residuary alkalinity" after evaporatio at 100 degrees C. The ratio between the carbonates formed at ordinar temperatures, and those remaining after evaporation, is seen to b approximately one twelfth in the case of the first series, and about on seventh in that of the second; the difference being, no doubt, due to th difference of temperatures employed in drying the residues, *i. e.*, 10 degrees C. and 105 degrees C. as against 110 degrees C. used by Weber but the law for intermediate ones remains to be determined.

It is of course to be expected that evaporation at ordinary tempera tures, such as usually occurs in nature, will yield results approximat ing much more nearly to those indicated by the titrations.

*It should be understood that in all cases, alkalinities expressed are in ccm. of norma standard H_2SO_4.

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TABLE No. 1.—*Experiments with Potassic Sulphate and Coarse-Grained Calcic Carbonate.*

Grams per Liter:	.25†	.50†	.75	.875	.9375	1.00	1.25	1.50	1.75	2.00	4.00
Total alkalinity*	9.95	10.15	10.80	13.25	14.10	14.20	14.30	14.48	14.54	14.60	14.80
Residuary alkalinity* after precipitation with alcohol	2.875	5.75	8.63	10.07	10.78	11.50	13.06	13.60	13.84	14.10	14.20
Corresponding $HKCO_3$ (per cent of total possible)	100.00	100.00	100.00	100.00	100.00	100.00	90.85	78.84	68.75	61.30	30.87
Amount $HKCO_3$ formed (grams per liter)	.287	.575	.863	1.01	1.08	1.15	1.31	1.36	1.38	1.41	1.42
Alkalinity corresponding to $CaCO_3$*	7.07	4.40	2.17	3.18	3.32	2.70	1.24	.88	.70	.50	.60
Evaporation residue 105° (grams per liter)	.837	1.195	1.314	1.492	1.625	1.743	1.908	2.175	2.452	2.747	4.725
Residuary alkalinity in same, grams $HKCO_3$ per liter	.035	.050	.070	.075	.080	.082	.084	.089	.092	.095	.120

TABLE No. 2.—*Experiments with Potassic Sulphate and Fine-Grained Calcic Carbonate.*

Grams per Liter:	.25	.50	.75	1.00	1.10	1.25	1.50	1.75	2.00	4.00	8.00
Total alkalinity* filtered solution	17.76	19.00	19.50	20.10	20.30	20.80	21.20	21.60	22.10	23.70	25.70
Residuary alkalinity* after precipitation with alcohol	2.875	5.75	8.63	11.50	11.80	13.10	15.00	17.40	17.80	23.20	24.70
Corresponding $HKCO_3$ (per cent of total possible)	100.00	100.00	100.00	100.00	93.28	91.12	86.90	86.43	77.39	50.43	26.85
Amount of $HKCO_3$ formed (grams per liter)	.287	.575	.863	1.15	1.18	1.31	1.50	1.74	1.78	2.32	2.47
Alkalinity corresponding to $CaCO_3$*	14.88	13.25	10.87	8.60	8.50	7.70	6.20	4.20	4.30	1.50	1.00
Evaporation residue 100° (grams per liter)	1.177	1.450	1.750	2.026	2.128	2.300	2.600	2.774	3.090	5.170	9.308
Residuary alkalinity in same (grams per liter)	.060	.100	.120	.140	.160	.190	.200	.210	.239	.250	.260

TABLE No. 3.—*Experiments with Sodic Sulphate and Fine-Grained Calcic Carbonate.*

Grams per Liter:	.25	.50	.75	.80	1.00	1.25	1.50	1.75	2.00	4.00	8.00
Total alkalinity* filtered solution	19.10	19.50	20.58	20.65	20.82	20.95	21.30	22.30	22.95	25.00	26.20
Residuary alkalinity* after precipitation with alcohol	3.521	7.05	10.57	10.60	12.58	15.60	18.04	18.60	19.30	24.10	25.20
Corresponding $NaHCO_3$ (per cent of total possible)	100.00	100.00	100.00	99.53	89.22	88.44	85.29	75.32	68.43	42.73	22.36
Amount $NaHCO_3$ formed (grams per liter)	.296	.592	.889	.890	1.057	1.290	1.515	1.562	1.621	2.024	2.117
Alkalinity corresponding to $CaCO_3$*	15.58	12.45	10.01	10.05	8.24	5.35	3.26	3.70	3.65	.90	1.00
Evaporation residue at 100° (grams per liter)	.924	1.190	1.785	1.840	2.052	2.307	2.571	2.880	3.140	5.276	9.332
Residuary alkalinity in same (grams per liter)	.035	.054	.084	.108	.113	.134	.168	.183	.223	.252	.259

* Cubic centimeters of normal standard H_2SO_4. † Data from Weber's previous work.

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EXPERIMENTS WITH SODIC SULPHATE.

A series of determinations was made with sodic instead of potassic sulphate, in order to determine whether the reaction follows the same law as in the latter, and if so, whether atomic proportions are observed from the outset; that is, from the weakest solution to the strongest.

Table No. 3 shows the result of this series of experiments. The first thing that strikes the eye in these results is, that while there is a general agreement of the progression, the sodic salt reaches sooner the point where complete decomposition ceases; that point lying at .8 grams per liter, instead of above 1.0, as in the case of the potassic salt. It will be noted that these figures approach closely to the atomic ratio, which should be .84 for sodium.

Continuing the comparison we find that the amounts of carbonate formed continue slightly higher for the sodic than for the potassic salt, until we reach in both 1.5 grams per liter, when the curves representing the progression diverge quite suddenly, the potassic salt increasing rapidly until, at the 8-gram solution, we approximate closely to the atomic ratio, the figures being 2.47 of potassic salt against 2.12 of sodic. The exact ratio would be 2.52 to 2.12, and would doubtless be reached at about the 10-gram solution for potassic sulphate. It thus appears that not only is the sodic salt transformed to a slightly greater extent than the potassic in very dilute solutions, but an inspection of the figures for "residuary alkalinity" after evaporation shows that larger amounts of the sodic salt are decomposed by high temperatures, falling considerably above the atomic ratio. But at 1.5 grams the amounts remaining undecomposed are in *atomic* proportions, and thereafter the sodic salt remains the more stable, until at eight grams the *absolute* amounts are equal, and therefore the atomic ratio is exceeded, the sodic salt being .259, instead of .218, to .260 of the potassic salt. It is to be expected that this greater stability of the sodic salt will be increasingly shown at lower temperatures, thus favoring the formation of "black alkali" under natural conditions.

There remains to be considered, so far as the present series of experiments is concerned, the quantitative relations of the calcic carbonate dissolved by the carbonic acid. The amount calculated as being precipitated by the treatment with alcohol of 60 per cent, is given in the fifth entry of the tables. The first point to be noted is that in the experiments made with the coarser carbonate the amount dissolved was very much less than in the finer grained, although an excess sufficient to maintain the reaction was always present.

The question may be raised whether the reaction was not influenced by failing to supply carbonic acid until the same amount of calcic carbonate was dissolved in each case. Against this objection we have thus far only the experiments of Weber, given above, and the fact that a true atomic proportion is reached where the amounts of lime present are smaller, viz.: in the strongest alkali solutions. It is intended to investigate this point at once to a definite conclusion, and the whole subject will be pursued into its ramifications with respect to the influence of the presence of other bases, and the variations of physical conditions, as rapidly as time will permit.

In the preceding experiments the reaction between alkali sulphates ready formed, calcic carbonate, and free carbonic acid, has formed the

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investigation. We have since entered upon and partially
a series of experiments in which the action of the carbonates
onates of the alkalies upon gypsum ready formed has been
g point, thus paralleling the case of mineral waters having
e reaction, and at the same time containing gypsum, with
hates, in solution. When such waters are evaporated the
eaction persists, while gypsum crystals are deposited; the
ve relations of the several compounds under such conditions
variations have already shown interesting points, which,
equire to be still further verified before being reported upon.
re prefer to reserve these data for the present, simply premis-
e results show that *any* excess of carbonic acid over the simple
onate at once establishes the possibility of the coëxistence in
olution of alkaline carbonates and earthy sulphates.

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V. FRUIT AND VEGETABLE PRODUCTS.

INVESTIGATION OF CALIFORNIA ORANGES AND LEMONS.

By G. E. Colby and H. L. Dyer.

(*Experiment Station Bulletin No. 93; June, 1891.*)

[A full investigation of the various fruits produced in California with respect to their proximate as well as ultimate composition has long been contemplated at this Station; but the fewness of the available workers and the heavy demands made upon them in other directions has until now restricted this somewhat laborious branch of research to occasional tests, such as have heretofore been published in respect to particular lots of fruit sent for examination. With the increased force now at hand it is proposed to investigate, as rapidly as may be, all the more important fruits produced on a commercial scale, so as to determine accurately the composition of the various kinds and varieties, both with regard to food value, and to the draught made by them upon the store of plant-food in the soils of the several regions. Since the latter vary very greatly in their nature, and therefore the replacement of the ingredients withdrawn by the crops will need to be made in accordance with the special requirements of each case in order not to "carry coal to Newcastle" at unnecessary expense, such investigations are of the most obvious practical importance; but at the same time they are extremely complex, and much time will be required to bring them to even a moderate degree of completeness. The work here discussed was entered upon in response to the constant demand of growers of citrus fruits for information as to the most appropriate fertilizers to be used by them. While it is far from complete, and will, of course, be continued and extended hereafter, it settles some of the immediately pressing questions. In the execution of the work, Assistant Colby had the benefit of the very efficient aid of Mr. Hubert Dyer, a graduate of the University, and post-graduate student in this department. Without such help we would have had to remain satisfied with a much smaller number of analyses, and a much narrower basis for conclusions.—E. W. Hilgard.]

The purpose of this work is to show comprehensively the proximate and ash composition of the leading varieties as grown in some of the principal citrus regions, and, inferentially, the influence exercised upon them by the prominent conditions of soil, climate, fertilizers, etc. The physical data (per cent of rind, pulp, juice, etc.) are of special interest from a commercial standpoint, as showing what is being purchased; for there can be no hesitation between an orange or lemon of average rind, pulp, and juice, and one of over one third its weight of undesirable rind and one quarter dry pulp.

The consumer, though usually considering fruit as a pure luxury, would derive much valuable knowledge from studying the orange in its relative value as a food. The nourishing portions, shown specially by

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genous and saccharine contents, vary greatly with the variety ditions of growth. It is not a matter of indifference to the r what fruit he uses, but an important question of domestic

h ingredients, together with the nitrogen contents of the stand- ties, are of high interest in connection with the vital question haustion and fertilization. The soil ingredients extracted by ary crop are a serious drain upon the supporting soil, and the heaviest draught can only be determined by analytic deter- of the constituents withdrawn.

Description of Oranges Received.

NAVELS.

Marysville, Yuba County.—G. W. Hutchins, grower; sample January 22d. A large, fairly solid, and heavy fruit, with rough n, indented ribs, and loose "rag;"* juice only fair in amount, nounced acid, and good flavor.

Niles, Alameda County.—Australian (?) Navel; J. Shinn, sample received March 30th. Undersized, rounded in shape, ose skin and "rag," with tender pulp and pleasant acid.

Niles, Alameda County.—Australian (?); J. Shinn, grower; eceived May 19th. Fruit differed in shape, being both rounded gated; base ribbed; both skin and flesh remarkably tender, "rag" ly moderately juicy, but of very agreeable flavor. Both Aus- ?) Navels were budded for Washington Navel by Mr. Shinn, ks, however, that the graft was taken from a sample tree of the an Navel.

Riverside, San Bernardino County.—"Washington Navel;" ox shipped to Professor Hilgard by Dr. Jarvis; grower un- received January 22d. It agrees well with a description of Navel, as given in Wickson's "California Fruits," page 451.

Riverside.—R. W. Meacham, grower; received May 12th. ange was selected by a prominent nurseryman of Riverside, nse to a request from this Station. A large, thick-skinned ith heavy "rag" and coarse pulp, much more elongated than cal Riverside Navel; some with base markedly depressed or aped, others flattened; acid, medium.

Pomona, Los Angeles County.—Palmer & Shaw, growers; April 10th; from trees six years old, on hill-land north of An average-sized fruit, high in color, but with thick skin, rag," and broadened fleshy base. On the whole a very desir- nge.

Pomona.—Selected by Short & Schwab, of Pomona, from a hipment, as "over-size;" received April 10th; from young trees ars) bearing only five or six oranges. Double the usual size, correspondingly coarse structure, although not unpleasant to ; decidedly "watery" as compared with Nos. 6 and 8.

Pomona.—L. M. Davenport, grower; sample received April n average-sized and thick-skinned fruit, of rather tender pulp eable acid.

* is the white tissue between the pulp and skin proper.

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MEDITERRANEAN SWEET.

Nos. 9 and 10. *Smartsville, Yuba County.*—Seedling, resembling Mediterranean Sweet; Jas. O'Brien, grower; sample received January 22d. Above the medium size, light-colored and smooth skin, and very sharp; sample apparently not quite ripe.

No. 11. *Riverside.*—R. W. Meacham, grower; received May 12th. Somewhat elongated; color yellowish red; skin thick and with sooty pits; very juicy; pulp tender.

No. 12. *Pomona.*—J. D. H. Brown, sender; received May 5th. Rounder in shape, smooth and rather thick skin; "rag" coarse; very juicy and slightly tart.

ST. MICHAELS.

No. 13. *Marysville, Yuba County.*—G. W. Hutchins, grower; sample arrived January 22d. Undersized as compared with those from Pomona and Riverside; medium heavy "rag" and rind; solid texture, but pulp melting, and acid high.

No. 14. *Riverside.*—R. W. Meacham, grower; sample received May 12th. Larger than the Pomona fruit but of the same general appearance, save that the skin is lighter colored; also of rather flatter taste, but very juicy.

No. 15. *Pomona.*—Exhibit at Los Angeles Citrus Fair; sample received April 10th. A larger and less compact orange than that from Marysville; of very thin skin and tender pulp; acid very pleasant.

No. 16. *Pomona.*—"Paper Rind;" from J. D. H. Brown; received May 5th. Round shape, smooth thick skin, and very good flavor.

No. 17. *Pomona.*—From J. D. H. Brown; received May 5th. Considerably larger than No. 16; skin thick, of elongated shape and agreeable taste.

MALTA BLOOD.

No. 18. *Pomona.*—Mr. Reeves, grower; sample received April 10th. Rather larger and more round than the typical specimen; skin moderately thick; pulp tender; seeds none; acid remarkably sharp; juice light-red color and of considerable quantity.

No. 19. *Pomona.*—J. D. H. Brown, sender; received May 5th. It agrees in size and shape with the previous sample, but has a thinner skin and "rag;" acid less pronounced; pulp melting.

No. 20. *Riverside.*—R. W. Meacham, grower; received May 12th. More elongated than those from Pomona, and of rougher and thicker skin; base heavy; "rag" porous; pulp not quite so juicy, but of deeper red color; somewhat "mushy," indicating overripeness.

VALENCIA.

No. 21. *Pomona.*—Sent by J. D. H. Brown, and received May 5th. This is known in South California as "Valencia Late," or "Rivers," or "Rivers' Late." According to H. Van Deman, it is identical with "Hart's Late" in Florida. He is of the opinion that properly the name should be "Nonpareil." It is about the same in size as the Mediterranean Sweet, but much larger than the St. Michaels, and of marked elliptical form; smooth thin rind, "rag" of fine texture, pulp melting.

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Place of Production.	
Marysville	G.
Niles	J. S
Niles	J. S
Riverside	Dr.
Riverside	R.
Pomona	Pal
Pomona	Sho
Pomona	L.
Smartsville	J.
Smartsville	J.
Riverside	R.
Pomona	J.
Marysville	G.
Riverside	R.
Pomona	Exh
Pomona	J.
Pomona	J.
Pomona	
Pomona	J.
Riverside	R.
Pomona	J.
San Gabriel	A.
Niles	J. S
Pomona	Sho
Ontario	Sho
San Gabriel	A.
Arroyo Grande	D.

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TANGERINE.

San Gabriel, Los Angeles County.—A. B. Chapman, grower; ceived April 11th. A small deep-colored fruit with loose thick fibrous texture of pulp; taste very sweet; acid low; flavor (like garden balm), but agreeable.

SEEDLINGS.

Niles.—J. Shinn, grower; samples received May 19th. A nd orange of light yellow color; base ribbed and fleshy; heavy, in; thick "rag," melting pulp, and exceedingly pleasant flavor. ppearance marred by coast scale and fungus.

Description of Lemons Received.

EUREKA.

and 25. *Pomona and Ontario.*—Two samples sent by Messrs. chwab, Pomona, April 10th. Of medium size, and with light e rather bitterish.

San Gabriel.—A. B. Chapman, grower; sample received h. Undersized; some markedly ribbed, and with very thick ds small and undeveloped; flavor more agreeable than in the Eurekas.

ARROYO GRANDE PRIDE.

Arroyo Grande, San Luis Obispo County.—D. F. Newsom, ample received April 22d. Undersized; smooth, heavy skin; o taste.

companying tables show the analytical work accomplished season (1891). Table A gives the physical and proximate Table B, the results of the analysis of the ash.

r to bring out more clearly than is shown by the tables the t points of similarity or difference, we discuss briefly the data

ORANGES.

ion of Rind to Flesh.—Considering the matter, first, from the t of the consumer, it seems that although the Navel is the oranges, it has, contrary to the popular impression, no advan- n respect to the proportion of skin to flesh, over either the nean Sweet or St. Michaels. The average Navel can fairly be d as containing nearly 72 per cent of flesh, while the average nean Sweet shows 73 per cent; the St. Michaels, 81 per cent.

ss, or Proportion of Juice to Flesh.—A comparison of the figures ge table shows that of the named-varieties examined the Navel est, while the St. Michaels has the largest proportion of juice, erranean Sweet being next, and the Malta Blood third.

acts will be better understood by reference to the little table ich gives the percentage ratios:

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Average Percentage Ratios.

Variety.	Proportion of Rind to Flesh.		Proportion of Pulp to Juice in Flesh.	
	Rind.	Flesh.	Pulp.	Juice.
Navel	28.4	71.6	39	61
Mediterranean Sweet	27.0	73.0	33	67
St. Michaels	19.0	81.0	31	69
Malta Blood	31.0	69.0	36	64

Evidently the hard and solid, although thin rind of the Navel weighs heavier in the balance than the more "corky" one of the Mediterranean Sweet, and doubtless outweighs, also, that of many seedlings. The Navel, No. 4, from Riverside, the Mediterranean Sweet, and No. 8, from Pomona, however, show the lowest rind-percentage of any in the series, save St. Michaels, No. 15, of Pomona, the genuine "paper rind." The study of the conditions contributing to thinness of rind will be of high commercial importance.

Sugar Contents of the Juice.—The table shows the maximum of sugar in the hill-grown Navel from Pomona (No. 6), but this is approached very closely by Navel No. 8 of Pomona, the Mediterranean Sweet, No. 9, of Smartsville, the Malta Blood, Nos. 18 and 19, from Pomona, and the Tangerine from San Gabriel, No. 22. It is notable that the latter shows at the same time the highest proportion of cane sugar to be found in the whole series, the Pomona Navels and Malta Bloods standing next. To what extent the proportion of *cane* sugar determines the sweetness to the taste is a matter not yet fully understood; the proportion between the other two sugars (grape and fruit), not yet determined, being an essential factor in the case.

The average sugar contents of the fully ripe Navels (gathered in April and May), from all localities, is 10.8 per cent. Against this we find the Mediterranean Sweets from Riverside and Pomona (Nos. 11 and 12, gathered in May) to average 9.70 per cent only; while the seedling from Smartsville, gathered in January, shows a little over 10 per cent, thus indicating a very early maturity.

The Valencia orange, from Pomona (No. 21), shows a decidedly lower sugar-percentage, as does the contemporaneous Malta Blood, from Riverside. The St. Michaels shows the lowest average of all the oranges (8.71 per cent), although the roundish sample from Pomona (No. 16) falls only a little below 10 per cent.

Comparing these data with those of previous years, heretofore published, we find that the sugar-percentage of the Navel appears to have risen from 9.89 per cent to 10.80 per cent. For the Mediterranean Sweet the figure remains practically identical. For the St. Michaels it is higher than we have found it this season.

Acid in the Juice.—In respect to acid, we note at once the maximum in Malta Blood, of over 2 per cent, with an average of 1.6 per cent in the three samples examined. The next highest figures occur in the early samples of Mediterranean Sweet, from Smartsville, a maximum of 1.68 per cent; but the average of the many samples from Riverside and Pomona is 1.23 per cent. The St. Michaels of Marysville (January twenty-second) shows the next highest maximum with 1.46 per cent.

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ne later samples of April and May we find in the Riverside No. 14) a minimum of .84 per cent, with an average of 1.07 ur later samples examined. In contrast to the Malta Blood, the St. Michaels counts among the varieties of low acid, com- wever, with rather a low sugar-percentage, as stated above. lencia rates, in the same respect, nearly with the St. Michaels, Tangerine shows the low figure of .87 per cent of acid, with, ame time, a very high sugar-percentage. A former analysis or its close relative, the Mandarin, a lower minimum of acid cent), and the highest sugar-percentage on record, or 13.84 per

vel justifies the statement made in a former report, of the low entage, even in samples gathered as early as January (Nos. 1 nd still more in those of later date from Riverside and Pomona nd 6). The minimum (.77 per cent) of all is shown by the ruit (No. 6), with, at the same time, the highest sugar-percent- 0) of the series. In the aggregate, the average acid-percentage vel (1.02) is the lowest of all, with the highest average of sugar cent) outside of the Malta Blood. These data, together with esh, thin and smooth rind, and excellent keeping qualities, ufficiently the great preference given it in our markets.

ring these results, obtained in 1891, with those in previous pub- of this Station, 1879–1887, we note, first, an apparent increase erage weight of the several varieties. We also find that while ntages of rind show very nearly the same average as in 1891, marked discrepancy in respect to juiciness, the pressed pulp about 25 per cent less in earlier specimens. How far these s may be due to influences of season or accident in sampling, is o decide with the data before us; the more so, as the acid and centages show very nearly the same absolute, as well as relative, Increased age of the bearing trees may possibly account for hese differences.

mona Navel from young trees (No. 7) is interesting, as showing an abnormally large orange differs from the ordinary fruit. It lly "watery" as compared with fruit of normal size.

editerranean Sweet (Nos. 9 and 10) are of special interest, y show the changes produced in an orange by two months' here is a considerable loss in weight, which is found in the ed weight of rind and flesh. Both the sugar and acid contents reased, the former so appreciably as to warrant the conclusion fruit was sweetened by keeping, apart from evaporation. It l on receipt of No. 9 that the sample was not thoroughly ripe, aste of the same fruit two months later was decidedly better.

ve Values—Nitrogen Contents.—The flesh-forming ingredients oids) of any article of food being of great importance as ts proper uses, it is of special interest to compare, in this he orange to other fruits, and the different varieties of oranges themselves. According to the latest European data, oranges t in the amount of albuminoids (1.73 per cent), prunes second cent), peaches (and probably apricots) third, bananas and urth, while apples and pears stand nearly the lowest on the 5 per cent). Our determinations of the same substances in a oranges, as a whole (rind included), show materially

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smaller figures, averaging 1.20 per cent; and as it is known that the rind is very poor in these substances, we are forced to conclude that the California fruit is less nourishing than that of Sicilian production; much lower percentages, however, are quoted for oranges from other sources.

Here, again, the differences observed may be largely due to the age of the trees bearing the fruit, which in California is usually the minimum.

Of the entire series the Riverside Navels (Nos. 4 and 5) show the highest contents of albuminoids (1.54 per cent), while the average of the Pomona samples is 1.18 per cent only. Next highest to the Riverside Navels come the St. Michaels from Marysville, Riverside, and Pomona, with an average of 1.40 per cent; nearly the same is shown by the Riverside Malta Blood. The average of the Mediterranean Sweets falls below 1 per cent, that from Pomona falling to .91 per cent. The Malta Blood and Niles Seedling show the minimum of .69 and .75 per cent, respectively. The Valencia and Tangerine, with the Eureka lemon, seem to range about 1 per cent.

Amount and Composition of Ash.—The table below gives in detail the amount and composition of the ash of representative samples of the several varieties. It will be noted that the average ash-percentage in the oranges is only four fifths of that in the lemons; also, that the average orange is somewhat richer in potash and in phosphoric acid than the lemon, but the latter takes up materially more of lime and less of magnesia. Potash is the prominent ash-ingredient most heavily drawn upon from the soil.

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Number	Variety.	Place of Production.	Percentage of Pure Ash.	Composition of the Pure Ash.												
				Potash	Soda	Lime	Magnesia	Peroxide of Iron	Br. Oxide of Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less Excess of Oxygen, due to Chlorine	Total
	ORANGES.															
1	Navel	Marysville	.399	55.26	1.39	16.37	5.50	.41	.28	12.41	6.81	.55	1.04	100.02	.23	99.79
4	Navel	Riverside	.451	49.07	3.30	26.42	5.08	.42	.44	9.80	4.23	.79	.63	100.18	.13	100.05
6	Hill Navel	Pomona	.407	47.51	3.06	17.50	6.33	1.41	.24	14.15	7.91	.98	1.00	100.09	.22	99.87
9	Seedling like Med. Sweet	Smartsville	.529	43.90	2.31	27.77	5.26	2.00	.18	13.10	4.34	.53	.59	99.98	.12	99.86
11	Mediterranean Sweet	Riverside	.413	51.25	2.41	18.78	4.76	.62	.32	14.46	5.58	.85	.92	99.95	.20	99.75
13	St. Michaels	Marysville	.477	47.60	4.09	24.70	6.36	1.18	.40	10.00	4.84	.38	.63	100.18	.18	100.00
15	St. Michaels	Pomona	.556	45.82	2.85	27.20	4.29	.97	.39	12.99	3.93	.31	1.37	100.13	.30	99.83
18	Malta Blood	Pomona	.454	52.20	1.48	19.07	4.75	.81	.64	14.71	4.29	1.06	.95	99.99	.20	99.79
22	Tangerine	San Gabriel	.461	47.87	1.67	26.85	5.48	.94	.45	9.75	5.36	.63	1.23	100.03	.27	99.76
	LEMONS.															
24	Eureka	Pomona	.632	45.32	2.03	34.07	4.00	.28	.28	10.19	2.74	.54	.51	99.96	.11	99.85
26	Eureka	San Gabriel	.535	51.20	1.50	25.67	4.80	.58	.28	12.00	2.94	.68	.27	99.92	.05	99.87
	AVERAGES OF ANALYSES.															
---	Oranges		.432	48.94	2.50	22.71	5.34	.97	.37	12.37	5.25	.65	.92	------	------	99.98
---	Lemons		.526	48.26	1.76	29.87	4.40	.43	.28	11.09	2.84	.66	.39	------	------	99.98

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Draught upon the Soil Ingredients.—As will be seen by reference to Bulletin No. 88, of this Station, the orange stands *second* (grapes being first) among orchard fruits in the quantity of mineral matter withdrawn from the soil. Heretofore we have been obliged to base all conclusions bearing upon the ash and nitrogen of these fruits on European data; we are now enabled to present for oranges and lemons the outcome of California growth. The following summary (based on averages from the large table) shows, in tabular form, the amounts in pounds of the soil ingredients extracted by an orange or lemon crop that will have to be replaced by fertilization:

Ingredients Withdrawn from the Soil by Citrus Fruits.

	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
ORANGES.				
European (seedless)—				
Crop of 1,000 pounds	6.07	2.78	.67	2.6
Crop of 20,000 pounds	121.40	55.60	13.40	53.8
California—				
Crop of 1,000 pounds	4.32	2.11	.53	1.8
Crop of 20,000 pounds	80.40	40.14	10.60	36.6
LEMONS.				
Crop of 1,000 pounds	5.57	2.69	.61	1.6
Crop of 20,000 pounds	111.40	53.80	12.20	30.2

It thus appears that so far as oranges are concerned, the California fruit draws materially less upon all the soil ingredients that have to be replaced by fertilization; while as regards the lemon, it approaches closely to the European standard for the orange, save in the much smaller draught upon nitrogen.

There is, of course, no material difference in the relative proportions of ash ingredients among themselves, or towards nitrogen.

Potash is seen to be the predominating ingredient, amounting to quite half of the weight of the ash; it is, therefore, highly important that the supply of this substance should be kept up; but fortunately, as has been shown by previous investigations of this Station, the supply of this substance in California soils and irrigation waters is exceptionally large, so that in many cases the current demand of the fruit will be amply supplied in the ordinary course of cultivation for many years to come.

Phosphoric acid is not very heavily drawn upon; but as it is usually present in our soils in limited quantities only, it is probable that it should constitute a large proportion of any fertilizer used in the orange orchard.

Of *nitrogen* nearly the same may be said as regards the natural supply especially in the southern mesa soils; and as the draught made by the orange upon this substance is very heavy, it will always be among the first to be currently supplied.

As regards other ash ingredients, it will be seen that *lime* is the one most heavily drawn upon next to potash, although its percentage varies rather widely (from 16.37 to 27.77 per cent for oranges). The supply of lime in California soils is almost universally so ample within the

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owing region, that no replacement of this substance in fertili-
ll be called for.
ot inconsiderable demand of the orange for sulphuric acid, as
ne table, suggests that gypsum will be acceptable in this as in
pects as a fertilizing ingredient.

LEMONS.

completeness of the data concerning lemons renders it inadvis-
ter upon any extended discussion; the more so as no extended
the Old World are available for comparison. It will be noted
nost important ingredient of this fruit, viz., the acid-percentage,
bly exceeds, for the Eureka lemon, at least, the commonly
average; and in the case of No. 26, from San Gabriel, the acid-
e is extraordinary. This point alone should insure to Califor-
lemons a high position in commerce.
latively large percentage of sugar shown by the analyses is a
hich will further commend them to the consumers' taste, as
ne percentages usually reported. It will be observed, however,
great differences exist in the proportion of rind to flesh and
le juice. In this respect the lemons of Pomona and Ontario
he head of the list as far as it goes.
composition there is no practically material difference between
ges and lemons examined; with a more extended series the
in both would doubtless be shown to run parallel.

ANALYSIS OF APRICOTS.

Early Apricot.—"*Pringle?*" The sample was received June 30,
Mr. B. F. Moore, Tulare.
erage weight was 24.8 grams, or 383 grains, eighteen being
to weigh a pound. The percentage of flesh was 90.9, the pits
ne remaining 9.1 per cent. The juice was found, on analysis,
pper (inversion) test, to contain 13.5 per cent of sugar.
ceeding sweetness of this early fruit was so striking as to ren-
termination a matter of curiosity as well as of some general
The result—13½ per cent of sugars in the juice—is the highest
16.5 per cent) we can find on record for apricots, the usual
iven being about 4.69 per cent in the whole fruit for European
This latter figure, however, refers to fruits grown outside of
, and we have yet to learn what is the usual percentage of
our standard canning and drying varieties of apricots.
ber of additional analyses of apricots are in progress at this
will be reported hereafter.

EXAMINATIONS OF SUGAR-BEETS.

ceptional perfection attained by the sugar-beet in California,
eculiar climatic advantages offered for the establishment of the
industry, having now been fully recognized and action taken
y capitalists, it becomes unnecessary for this Station to repeat

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hereafter what for eleven years past has formed "the burden of its song" in every report, although derided and systematically belittled by more than a few of the present enthusiastic converts. It now behooves more, perhaps, to preach caution against unwise efforts to establish the industry where it is not likely to prove successful, from the very fact that certain localities appear to enjoy such distinguished advantages of soil and climate that others, less favored, cannot reasonably hope to compete with them. It is therefore intended, not only to test the culture of the several varieties systematically at each of the culture stations, but also to distribute seed to those who desire to make private tests and to send the roots for assay to the station at Berkeley. The transmission of such samples for this purpose from all parts of the State is invited, in order that by the systematic comparison of results the greater or less adaptation of the several climatic divisions may be ascertained, as speedily as possible.

One of the most important points to be elicited by experiments is the season within which successive plantings of beets may be made, so as to prolong, as much as possible, the duration of the "campaign" of the factories. Personally, the Director does not as yet abandon the hope that in certain regions, at least, the *drying* of beets may be made feasible by proper appliances, thus extending the possible activity of the factory-plant through the whole year.

SUGAR-BEETS AT FRESNO.

(*Experiment Station Bulletin No. 72; August, 1887.*)

The culture of the sugar-beet in the San Joaquin Valley has, until lately, remained a bare suggestion. It is well known that they have been successfully grown near Isleton and Sacramento, on the moist lands of the Sacramento River, on which irrigation is unnecessary. It is doubtful that the sugar-beet has ever before been cultivated where irrigation is indispensable, and this fact, as well as the high summer temperature of the southern valley, has discouraged the attempt. In fact, the very idea of a root filled full of irrigation water, and then wilted by the torrid heat, is enough to excite the antipathy of the manufacturer.

The success of the sugar-beet near Los Angeles, however, encouraged the hope that, with a proper selection of soil, and of the time of planting and irrigation, a root suitable for the sugar-maker might be produced in the San Joaquin Valley; and if so, that the crop might be made to supplement that of the coast valleys, so as to prolong materially the annual campaign, the shortness of which is a heavy charge on the capital invested in the somewhat costly plant of beet-sugar factories. As stated in a paper on the subject, published in the December number of the "Overland Monthly," 1886, the campaign period in Europe usually does not much exceed three months—October, November, December—while in California, owing to the favoring climatic conditions, there is no difficulty in lengthening it to the five months, from September to January both inclusive. If, by early sowing in the precocious season of the upper San Joaquin, two or three months more could be added to the time of campaign, it would place beet-sugar production in this State on a ground of vantage, from which it might calmly defy the competition of its tropical competitor, the sugar cane.

Preliminary experiments to test the feasibility of growing good suga

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er the condition of the Fresno climate have, during the present
een made by Mr. M. Denicke, of Fresno. Mr. Denicke obtained
mn from Mr. Dyer, of Alvarado, some reliable sugar-beet seed,
d it at intervals from December to April. The results of the
ion of four lots, planted and harvested as stated below, were as

1.—Seed sown in December, harvested May twenty-seventh.
onsisted of four roots, two of which (A) showed just an indica-
ew growth starting in the center, while in the two others (B)
ed-stalk was already formed, so that they had evidently passed
r stage for sugar-making.

2.—Two beets from seed planted early in April by Mr. L. J.
, on sandy, ashy soil, on Kings River, six miles east from
Harvested June twenty-sixth. Little or no indication of new
arting.

3.—Two roots. Seed sown about March fifteenth, on "white-
Harvested June twenty-ninth. Somewhat fresh-looking in
, but no serious show of new growth.

4.—Date of sowing not stated. Roots in good apparent con-
Harvested August fourth.
ays resulted as follows:

Assays of Fresno Sugar-Beets.

Lots.	Sown.	Harvested.	Average Weight, Ounces.	Cane Sugar, Per Cent.	Purity Coefficient.
.....	December.	May 27....	21	10.1	82.6
....	December.	May 27....	24	7.0	70.0
.....	April 10?..	June 26 ...	18	10.5	80.7
.. ..	March 15?.	June 29 ...	22	12.6	82.0
.....	?	August 4..	25	13.2	75.3

egard to the data in this table, it should be stated for the
the general reader that roots having an average of 10 per
ane sugar and a purity coefficient of 80 (that is, 80 per cent
ugar in the total solid contents of the juice), would be consid-
r workable material by the European sugar-maker. But a
gar per cent in the juice may offset a lower degree of purity,
ersa.

be noted that the average of the first three lots (leaving out
eration lot 1 B) is 11.1 per cent of sugar, with a purity coeffi-
1.4; they are, therefore, quite within the limits stipulated by
-maker. As for lot 1 B, the fact that the roots had begun to
seed-stalks shows at once that they had passed beyond the
in which the crop should have been harvested. I conjecture
growth had been started by untimely irrigation. As for lot 4,
it shows a somewhat higher sugar-percentage than No. 3, its
ity coefficient would nevertheless render it less desirable as it
ut the appearance of the roots suggest, in this case, also, that
r time for harvesting had passed by.

ering that the persons growing these beets were without ex-
n the premises; that, in fact, irrigation had never before been
o the production of sugar-beets, and that the right time and

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the proper amount must in this case be considered as at least equally as important as in the case of wine grapes, the results obtained are exceedingly encouraging. They imply that in middle California the working campaign for sugar-beets can very probably be extended through the months of June, July, and August, making it reach from June first to February first; and considering that the beets of the first lot had already passed their best condition by a week or two, and that with somewhat improved arrangements for the preservation of the late-grown beets, they can probably be carried to the middle of February, we can foreshadow the possibility of such an extraordinary feat as an *eight months'* campaign of a beet-sugar factory running on fresh beets. With the additional possibility of utilizing beets sliced and dried, under the same conditions as the raisin crop, the full twelve months may ultimately be called into requisition.

It must, however, be remembered that in order to realize such results, it must be feasible to bring the beets of the San Joaquin Valley, and those of the coast valleys, within reach of one and the same factory plant. The roots will not bear railroad transportation to any distance; but with cheap water transportation it might be feasible to let the crops of Fresno and Merced start up the factories located in the upper bay region in June, and to keep them running until the middle of February by supplies from the coast region. It is to be hoped that more extended and carefully guarded experiments will be made the coming season, even if the omission of Congress to render the Experiment Station Bill effective by means of an appropriation should not be made good in time.

ANALYSES OF SUGAR-BEETS.

Sugar-beets, from eight miles north of Santa Rosa, Sonoma County, on the Calistoga road; sent by Mr. E. E. Sawyer, Santa Rosa, October 14, 1890. The seed, obtained from the University Experiment Station, was planted on May 17, 1890.

Sample *No. 1* was grown on sandy, alluvial soil, in the bed of the Marl West Creek. Its weight was 1,085 grams (2.3 pounds), and the specific gravity of the juice, 1.0766; the solid contents of the juice amounted to 18.50 per cent, of which 15.80 per cent was cane sugar and .80 per cent was ash. The purity coefficient was, therefore, 85.40 per cent; and this with the high sugar content, places these beets far above the minimum required for profitable working. It is a first class beet in every way and makes an excellent showing, especially for so large a root, which was a little above the weight generally admitted by the factories.

Sample *No. 2* was grown on an upland soil, which fairly represents the greater part of the land of the vicinity. The weight of the sample was 330 grams, and its specific gravity, 1.0434; the solid content amounted to only 10.80 per cent, with a very small content of sugar, which places it far below par.

Sugar-beets from the Chino Ranch, San Bernardino County; sent by Mr. Richard Gird, Chino. They were grown upon a dark sandy loam soil, and from the Klein von Slavin seed, and were received in good condition July 16, 1890, nearly five months from planting.

Sample *No. 1*, comprising three beets; the seed was planted February 24, 1890, at a distance of four inches in rows fifteen inches apart. The

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raged 600 grams in weight, and yielded 280 ccm. of juice, with a ravity of 1.0875. The solid contents of the juice amounted to nt, of which 13.55 per cent was cane sugar. The purity coeffi-s, however, only 64.50 per cent, or 10 per cent below that at is held that beets can be profitably worked; the percentage of gar" is too great.

e *No. 2*, comprising one beet, was from the same seed planted at of six inches in rows fifteen inches apart. The beet weighed s, and the amount of juice was 420 ccm., having a specific gravity The solid contents of the juice were 17.90 per cent, of which cent was of cane sugar; the purity coefficient was, therefore, ich, with the small sugar content, places the beet far below the n of profitable working. It was probably immature.

beets from Watsonville, Santa Cruz County; sent by Mr. N. D. Watsonville, October 16, 1891. The average weight of the two was 600 grams, or 1.3 pounds; the juice had a specific gravity ; the solid contents were 19.3 per cent of the juice, of which cane sugar, and .60 per cent was ash. The purity coefficient re 87.1 per cent, or 12 per cent higher than the minimum for working. The content of cane sugar is also higher than d nearly 5 per cent above the average richness of beets used in nufacture in Europe. These samples are as fine as any thus ned in the State, and it is unfortunate that the variety of seed, nature of the land, both physical and chemical, are not known.

beets from the Foothill Station, five miles northeast of Jackson, County. These samples, representing five different varieties, wn upon the red slate soil (No. 1113) of the station tract, which ious report is thus described: An orange-red loam, the lumps are easily crushed between the fingers when dry, and show ble coarse sand. When wetted it becomes only moderately while its color darkens materially. Slate fragments are inter-more or less all through, much of the sand being comminuted he vegetation on this soil comprises yellow, sugar, and nut two mountain live oaks, black, white, and blue oaks, buckeye, n, toyon, manzanita, madrone, spiny chaparral, poison oak, or mac. Among the herbaceous growth the yerba santa, several sses, the alfilerilla, and several native clovers were conspicuous.

oil (No. 1114), from twelve to twenty-four inches in depth, is glaringly orange-red tint, the lumps of which, when dry, can crushed between the fingers. Its color hardly changes on ut it becomes quite adhesive when kneaded; like the soil, it uch coarse sand and some slate fragments. This material ere to depths of three to five feet, with increasing number of ments.

lowing analyses give the composition of the soil and subsoil:

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Sugar-Beet Soil of the Foothill Station.

	No. 1113. Soil.		No. 1114. Subsoil.	
Coarse materials > 0.5mm	19.20		7.86	
Fine earth	80.80		92.14	
	100.00		100.00	
Analysis of Fine Earth.				
Insoluble matter	49.96	64.92	40.98	62.16
Soluble silica	11.96		21.23	
Potash (K_2O)	1.48		1.82	
Soda (Na_2O)	.43		.43	
Lime (CaO)	.60		1.37	
Magnesia (MgO)	2.21		2.28	
Br. ox. of manganese (Mn_3O_4)	.05		.05	
Peroxide of iron (Fe_2O_3)	11.52		11.89	
Alumina (Al_2O_3)	12.31		14.06	
Phosphoric acid (P_2O_5)	.05		.07	
Sulphuric acid (SO_3)	.02		.02	
Water and organic matter	6.63		5.62	
Totals	100.22		99.79	
Humus	.54		.18	
Ash	.80		.33	
Sol. phosphoric acid	.03		.01	
Silica	.60		.19	
Hygroscopic moisture (absorbed at 15° C.)	5.74		6.59	

The potash percentage in the above is very high; the amount of lime though not very high in the surface soil, is abundant in the subsoil direct determination shows .04 per cent to be in the form of carbonate The percentage of phosphoric acid, as usual in California upland soils is not high, but very largely in the soluble form. The amount o humus is rather low. For the special culture of the beet there is an ample supply of potash, lime, and phosphoric acid, but probably a deficiency of humus, the reservoir for nitrogen compounds so important for the thrifty growth of the plant; it having been found that "roots which bear leaves of a broad surface are generally more rich in sugar than those having small leaves upon a contracted top."

The five varieties of sugar-beets were sown May 6, 1890; the bottom leaves turned yellow September twenty-sixth; were harvested November third, and forwarded to Berkeley February 2, 1891.

Though sown on both the granite and red land, the samples forwarded were of the red soil only. Those on the granite soil were beaten down by the rain and covered with such a thick and impenetrable crust that the beds could not very well be reclaimed for that season; the few plants coming up were of no use. Those on the red soil received occasional irrigation from the seepage of the vegetable patch close by. They were also hoed three times; no manure of any kind was applied. The piece of land in which they were grown is considered the richest part of the red soil, but as it contained little or no sand, it is not very well fitted for cultures which must be hoed; the ground bakes and forms a troublesome crust, which cracks in the sun as soon as irrigation is given.

The samples were received on February 11, 1891, and analyzed on the next day, with the following results:

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Analyses of Sugar-Beets from the Foothill Station, Amador County.

	No. 1. Bulteau Deprèz (Richest).	No. 2. Florimond Deprèz (Richest).	No. 3. Dippe's Kleinwanz-lebener.	No. 4. Simon Le Grand White Imp.	No. 5. Dippe's Vilmorin.
eight of sample	320.0	371.7	380.0	326.6	385.0
nount of juice	186.6	183.3	208.3	183.3	210.0
vity of juice	1.0744	1.0687	1.0652	1.0713	1.0647
nts of juice	18.00	16.70	15.90	17.30	15.80
per cent of juice	14.13	12.79	12.82	12.96	13.38
icient	78.50	76.60	80.63	74.90	84.64
cient	16.05	14.50	19.13	21.20	17.3
nt of juice	.88	.89	.67	.61	.77

he varieties are below the average weight, but all fall within ts regarded at the factories as profitable for working, though reatly in sugar contents and purity coefficients.

lteau Deprèz has the largest percentage of solid contents as sugar, though its purity coefficient is low. The percentage somewhat greater than desirable, and militates against the alue of the sample.

orimond Deprèz would probably be rejected at the factories f its low purity coefficient and rather high ash-percentage, aving a fair sugar content.

ope's Kleinwanzlebener ranks very well with a good sugar con- gh purity coefficient, and a low ash-percentage.

non Le Grand White Improved has in its juice a large amount ontents, which, though its sugar content is good, places the fficient quite low and within the danger limit; its ash is for- ow.

ope's Vilmorin is, seemingly, the best of the varieties, with a entage of sugar, and a high purity coefficient, though its ash ously high. It is questionable whether its value as a sugar- ove the Dippe's Kleinwanzleben, which has a lower purity , but at the same time a much lower ash-percentage.

eets from the Southern Coast Range Station, two miles from les, San Luis Obispo County. The seed was sown on May 5, the crop harvested on October 6, 1890.

e samples, representing as many different varieties, were grown dy loam soil (front land soil No. 1147), which consists mainly c sand, intermingled with white hornstone and claystone debris, which is little, if at all, waterworn. A small, but somewhat proportion of clay, serves as a binding material, which gives ough consistency to turn a furrow slice, and to prevent leachi- e tree growth consisted almost exclusively of the blue oak, with all white oaks. The soil is of a reddish-gray or fawn color, epens considerably on wetting, by bringing out the color of the esent; but it can hardly be said to assume any plasticity, and dently be safely plowed almost at all times.

mposition of this soil, as reported previously, is as follows:

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Sugar-Beet Soil of Southern Coast Range Station.

	No. 1147. Sandy Loam Soil.	
Coarse materials >0.5mm	39.5	
Fine earth	60.5	
	100.0	
Analysis of Fine Earth.		
Insoluble matter	85.12	90.69
Soluble silica	5.57	
Potash (K_2O)	.68	
Soda (Na_2O)	.31	
Lime (CaO)	.34	
Magnesia (MgO)	.37	
Br. ox. of manganese (Mn_3O_4)	.04	
Peroxide of iron (Fe_2O_3)	3.83	
Alumina (Al_2O_3)	1.74	
Phosphoric acid (P_2O_5)	.07	
Sulphuric acid (SO_3)	.03	
Water and organic matter	2.19	
Total	100.29	
Humus	.66	
Ash	.79	
Hygroscopic moisture (absorbed at 15° C.)	1.84	

"The sandy nature of this soil is well shown in the large proportion of inert matter and the low moisture-absorption; so low, in fact, that but for the great depth at all points it would constitute a serious defect, and would necessitate very frequent irrigation. But as there is a scarcely noticeable change in the nature of the soil for eight feet or more, both moisture and nourishment can be brought up by the roots independently of the surface soil. As a matter of fact, however, moisture, sensible to the hand, is always found in this land at a depth of six or eight inches, and the roots of smaller plants are usually found unhurt by drought or heat much nearer the surface. There is an abundance of potash present with a relatively small proportion of lime, which, however, does not amount to a deficiency in so sandy a soil, and still imparts to it the characters of a calcareous one. For so sandy a soil, again, the supply of phosphoric acid is quite large, especially in view of the great depth to which the roots can readily go. The supply of humus is only fair, and might be advantageously increased."

Physically, this soil seems well adapted to the culture of the beet, possessing, as it does, depth, moisture, porosity, lightness, and good drainage. In its chemical character, however, while there is an abundance of potash and phosphoric acid, and perhaps of lime, there is lacking the humus which, as the store-house for nitrogen, is so important for beets, and to whose deficiency may be due the relatively low grades produced on this soil, as shown in the following table giving the tests with five varieties of seed:

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Sugar-Beets from the Southern Coast Range Station, San Luis Obispo County.

	No. 1. Florimond Deprèz.	No. 2. Dippe's Vilmorin.	No. 3. Simon Le Grand's Improved.	No. 4. Bulteau Deprèz.	No. 5. Dippe's Kleinwanzlebener.
ght of beets					
	120	690	750	885	580
uice (ccm.)	650	300	400	425	250
ity of juice	1.0530	1.0674	1.0630	1.0610	1.0570
s	13.1	16.4	15.4	15.10	14.10
		12.44	13.06	10.71	
ient		75.85	84.15	71.45	

e varieties, there are but two which are above the minimum rofitable sugar-making, viz.: the *Dippe's Vilmorin*, which is hin the limit, though its sugar content is fair, and the *Simon s Improved*, whose sugar content and purity coefficient are le above the average. Supposing that the conditions attend- lture of all of the varieties were similar, the latter variety is best and the only one adapted to this soil. By reference to s of the Foothill Station, given on a previous page, it will be here this variety does not take precedence, but ranks second.

TIVE TANNIN ASSAYS OF CAÑAIGRE ROOTS GROWN IN CALIFORNIA.

Graduating Thesis, by CHARLES S. BONNER, Class of 1890.

aigre is the root of a species of dock (*Rumex hymenosepalum*) ws wild in Texas, Arizona, New Mexico, Southern California, of Mexico. It has been long used for tanning purposes by ns, and also of late years by the tanneries of those districts. s use has been very limited in the past, it is highly probable ccount of the large amount of tannin in the root, its culture eatly extended, and that it will become a very general and anning material. As it grows well, in its native country, in a soil, almost unavailable for any other purpose, many parts te might be advantageously employed in growing it, provided ic conditions are favorable.

to test the growth of the plant in this State, some of the roots ted in the University Experimental Garden, at Berkeley, in now shows a vigorous growth. The tuberous roots are very ustered at the base of the plant, and are nearly all of large samples of which these analyses were made, with the excep- o which came from Colton, California, were taken from roots nts grown at Berkeley. The results of these analyses were actory, showing that the plants will flourish as well and store h tannin in its roots in this State as in its native country. e samples from Berkeley gave a very much higher tannin-per- an was found in a root from Texas, the analysis of which is he report of the United States Department of Agriculture for 878. The latter gave but 26 per cent of tannin, while the f the analyses, summed up below, is about 36 per cent. oot from Texas, however, was analyzed in the Agricultural

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Laboratory at Berkeley (report for year 1884), and gave 38 per cent which will be seen to agree very closely with the results given below.

Internal Structure of Root.—The root of this plant resembles a swee potato in shape, varying in diameter from one half an inch to two inches Upon cross-section it presents a somewhat concentric cell-structure The texture of the root is soft and delicate throughout, with the excep tion of a zone near the outer surface, which is of a firmer, more woody fiber. In an ordinary root of about an inch and a half diameter, th woody zone would be about one quarter of an inch thick, and would b situated between the inside core of soft cellular matter—from thre quarters of an inch to an inch in diameter—and an outside narrow zon of soft matter, not more than an eighth of an inch in thickness. Whe freshly cut, the softer tissue is colored a bright yellow, which, on expos ure to the air, changes gradually to a reddish brown, the woody laye being white. Through this white matter, however, are found concentri rings of yellow. Some of the roots have only a small amount of colo ing matter.

Microscopic Character of the Root.—The cell-structure of the root i very delicate in all parts except the woody fiber, the cells of which ar very much thicker than the others. The partial yellow coloration of th root is due to a yellow oil or resin, which completely fills a great man of the cells. In the woody fiber, which to the naked eye appears to b colorless, these yellow cells are also found, but very much more di persed than in the other parts. A great many ducts run through th part of the root, and around these the yellow cells are collected in larg numbers, giving rise to the appearance of the concentric rings of yello matter spoken of above.

Starch grains are very thickly scattered through the whole root. Th analysis of the root found in the report of the Department of Agr culture, before mentioned, gave 18 per cent of starch. These grain when viewed under the microscope, had every appearance of starc grains, and it was attempted to stain them with an iodine solutio The iodine, however, did not diffuse sufficiently through the cell mem branes to give a characteristic reaction, and it was necessary to use th powdered substance to get a satisfactory test. The starch grains coul then be distinctly recognized, colored by the iodine.

Location of the Tannin.—Besides the cell walls, the yellow coloring matter, and the starch grains, nothing can be seen which would sho that the tannin is in any other form than in solution. This conclusio was regarded as the only possible one, and it was attempted to color th tannin with an iron compound (ferric sulphate and chloride being used for examination. The results, however, were not very satisfactory. Th iron salts did not seem to diffuse thoroughly through the cells, althoug sections of the root were allowed to soak for over twelve hours in th mixture, and the coloration was confined to the cell walls. The failu of the iron salts to diffuse through the membranes was possibly due the formation of the insoluble tannate of iron directly upon the ce walls. The sap, however, wherever squeezed out of the root, gave characteristic coloration, with ferric chloride; and even the knife-blad used in cutting sections, was covered with a black stain. Thus, the pro that the tannin is in solution in the sap of the root, seems conclusive.

Determinations of Tannin.—The method employed in making the tannin determinations was, to extract with ether, evaporate to drynes

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n water, and titrate for tannin. The ether solution contains, ne tannin, the yellow coloring matter, which is slightly soluble and almost insoluble in water. The amount of coloring matter by the ether is quite small, so that the weight of the extract, poration of the ether, should be but little more than the tannin titration. This weight was used in all cases as a check upon The percentages were calculated upon the substance dried grees C.

statement below, samples Nos. 1 and 2 were from Colton, Cal. very much blackened and apparently decomposed, which is verified by the result of the analysis.

8 were from Berkeley, and were gathered on April 10, 1889.

as also from Berkeley, but was gathered May 20, 1889.

and 2 compared, show the amount of tannin found in the same ed in different ways. No. 1 was sliced and dried, and No. 2 whole. Both roots were very small.

and 4 give a comparison of the amount of tannin in roots of colors.

and 6 were compared to show where the tannin is principally in the root. This knowledge is of practical interest.

and 8 give a comparison of the amount of tannin in small and oots.

Determinations of Tannin in Cañaigre Roots.

Character of Sample.	Ether Extract —Per cent.	Tannin—Per cent.
liced and dried	16.90	16.90
ried whole	7.65	6.09
ith little coloring matter	35.76	34.76
ith large amount of coloring matter	39.50	35.14
e sections of root	33.49	31.20
sections of root	47.97	45.80
root	43.93	41.79
root	40.77	38.51
otained May 20, 1889	35.06	34.12

and 2 give very poor results. No. 2, as has been stated, was ble, and gave evidences of being decomposed. None of the the root was visible, its appearance being similar to a compact body. From this fact the following conclusion of practical ce is to be drawn, viz.: that on account of the extreme liability s solutions of tannin to decomposition, it is necessary, in order he roots without deterioration, to facilitate and hasten the on of water by cutting them into thin slices.

mparison of Nos. 3 and 4, it will be seen that the tannin-per- ears no direct relation to the amount of coloring matter in It is also seen that the coloring matter is more or less soluble and to a less degree in water. The tannin per cent of No. 3 t-colored root) was very nearly equal to that of the ether 35.76 per cent; the ether extract corresponds to 34.76 per cent nnin). Comparing this with results of No. 4, the dark-colored

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root, we find that 39.5 per cent of ether extract gives only 35.14 per cent of tannin.

Distribution of the Tannin in the Root.—From a comparison of Nos. 5 and 6, we see that the inside parts of the root give more tannin than the outside. The samples were taken so as to divide the roots into very nearly equal parts, cutting out an inside core about equal to one half of the root. These samples gave very wide differences in results, as would be expected. The woody layer being quite near the exterior surface, was cut with the outside sections. This woody tissue contains a very small amount of tannin, as compared with the other parts of the root, as may even be easily detected by the taste. This is natural, as the tannin is, doubtless, in solution in the sap of the root, and would therefore be confined mostly to the softer and growing parts.

The smaller roots contain less of the thick and heavy woody tissue and more of the soft growing parts, and therefore give a large percentage of tannin, as will be seen from No. 7. No. 8, a very large root, gave more tannin than was found in most of the other roots; but this is probably not due to the size of the root, all being liable to vary more or less in the tannin-percentage.

Time of Gathering.—Sample No. 9 is of a root picked May twentieth having been allowed to remain on the plant nearly six weeks longer than the others. It does not show any increase in tannin over Nos. 3 and 4, thus showing that the roots may be gathered at any time after the plants have ceased flowering.

PRESERVATIVE FLUIDS FOR FRESH FRUITS.

By E. W. Hilgard.

(*Experiment Station Bulletin No. 86; May, 1890.*)

As the fruit season approaches there is a constant inquiry for some mode of preserving fruit samples for exhibition at the several fairs. As a general answer to inquiries of this kind that have already come dropping in, I give the following data in regard to the more successful preservatives that are within reach of the practice of any intelligent farmer. I preface them with an explanation of the demands made upon such preservative methods, for the benefit of those to whom the subject may be new, in order that they may better adapt their practice to circumstances.

1. *The preservatives must prevent all fermentation, moulding, or other fungous attacks.* This, of course, means that the outside of the fruit, and the air or the liquid around it, shall be "sterilized" in some way compatible with the preservation of the form, at least, of the fruit or vegetable. This, again, excludes any considerable heating, such as is necessary in "putting up" fruit for eating purposes. We are practically reduced to the use of antiseptics, acting at the ordinary temperature. Among these we have to choose between gases and liquids; but as the manipulation of gases does not come within the condition of easy practicability in an ordinary household, we are further confined to the use of liquids only; the more, as these help to prevent damage in transportation, by removing the greater part of the weight of the individual fruits, that would otherwise tend to deform them. Hence,

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preservative should be a liquid. This liquid, besides being an antiseptic, should not exert any solvent or softening action skin of the fruit. This condition excludes from the outset *ne* solutions (such as, *e. g.*, cyanide of potassium, silicate of and all the stronger acids, including acetic acid or vinegar.

antiseptic fluid should not extract or change the color of the fruit. e of the most difficult conditions to fulfill, and yet one of the ntial. It excludes at once so excellent a preservative as alco- nany others that would otherwise be available; among others, alt, which is available at most for green fruit.

preservative fluid should neither cause the fruit to swell, so as to s size, and sometimes burst it; *nor should it have the opposite using it to shrink.* This implies that in the exchange that oidably occur between the juice inside and the fluid outside, all pass through the skin with about equal rapidity. Accord- l known physical laws, this necessitates that the two liquids approximately of the same density. Thus, if the fruit to be were grapes containing a juice showing 25 per cent by spin- uid outside ought to be made of the same density. If not, vill either shrink or swell, at least at first; in some cases the ulk will ultimately be recovered; but usually, particularly kinned fruits, the change is more or less permanent. Thus, g ripe olives, the size of the fruit may be materially reduced, substance toughened when too soft, by the use of strong brine. is preëminently true of fruit preserved in alcohol or in strong

er, then, may be the kind of antiseptic employed, this condi- proximately equal densities of the fruit juice and preservative be fulfilled if the former is to maintain its natural size, espe- ne fruit be soft or thin-skinned.

of sugar to bring up the antiseptic solution to that of the naturally suggests itself, and with some fruits very good y be obtained in that way. Still, sugar itself being easily fer- nd liable to change tint when not very pure, it is preferable *erine*, which can now be obtained so cheaply as to render it o all, and which is, for practical purposes, unchangeable when According to actual trial, commercial "pure" glycerine will tisfactorily when used per cent for per cent *by weight* in place To do this by *liquid measure*, use four fifths per cent of gly- qual to one per cent of sugar. Like alcohol, however, glycer- a slight solvent action upon many fruit colors, *e. g.*, that of lackberries, etc.

salt has the disadvantage of darkening all vegetable colors nparatively short time; and *Glauber's salt*, *alum*, and other available salts exert a not inconsiderable solvent action upon ch renders their use inadvisable.

always, of course, easy to ascertain the density of the juice ut the housewife or farmer may rest content with the follow- imations to the soluble matters of fruit juices for *ripe* fruit:

ears, about	12 per cent.
s, apricots, and peaches, about	10 per cent.
ut	12 per cent.
about	8 per cent.
	10 per cent.
lifornia	18 to 30 per cent; average, 24 per cent.

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It is only in very tender-skinned fruit that a per cent or two, more o less, will make a difference in the result.

Of antiseptics, the following are the most available: *Salicylic acid boracic acid, sulphurous acid* and its compound, *bisulphite of soda* (an of lime), and last but not least, *bichloride of mercury*, or corrosive subli mate.

Salicylic acid, or its compound with soda, both obtainable in commerce is one of the best and most energetic antiseptics. Its use in spirituou fluids is but too well known; in watery solution it is not so much used on account of some difficulty in making it dissolve, particularly whe the water is cold. An ounce of the acid dissolves in a little less tha five gallons of water at the ordinary temperature; but when it is simply thrown *on* the water it may float there a long time, being very light, an many persons will think that it will not dissolve in that proportion. I hot or boiling water there is no difficulty, and the solution is made ver easily by the addition of a little carbonate of soda (sal soda) even with out heating. But when making use of the soda *it is absolutely necessar to avoid an excess*, as the uncombined soda exerts a very injurious influ ence upon the preservation of fruits. *A solution of one ounce of salicyli acid to five gallons of water, to which as much glycerine has been added a corresponds to the density of the fruit juice* (see above), constitutes a pre servative fluid which has been used with very satisfactory results here tofore. Trouble has arisen from the use of too much soda in makin the acid dissolve; as already stated, with patience or heating, the wate alone will dissolve the acid, and soda need not be used at all.

Boracic acid, while an excellent preservative so far as the mere pre vention of decay or fermentation goes, is more liable than the salicylic t soften the skin and alter the colors of fruit, acting in that respect, i some cases, like alkaline solutions. It is, therefore, not well adapted t long conservation of samples in their natural aspect, but will do well fo a few weeks with most fruits. Use the solution as strong as water wil make it, which is about five ounces per gallon.

Sulphurous acid, the same substance of which the use is so muc abused in fruit drying and in the treatment of wines, can also b employed in solution for the preservation of fruits. This solution ma be made directly from the gas of burning sulphur—by an operatio sufficiently familiar to cellarmen, and described below. It is, howeve more convenient and just as good to use in combination with soda, viz the "bisulphite" of soda (not that of lime, used in bleaching saccha rine juices, as it will form deposits upon most fruits), heretofore sol under the fanciful name of "California Fruit Salt," and recommende for use in canning fruit for human consumption. Those whose diges tion is better than necessary, and who do not object to the sulphurou flavor of the fruit so preserved, may choose to use the preparation. I merits as an antiseptic are unquestioned; its bleaching effects are equall so, and, as in sulphuring wines, the natural colors will suffer more o less from its use, as well as from that of the acid solution. Use five t eight ounces per gallon.

The following mode of preparing a preservative fluid with sulphurou gas, obligingly communicated by Manager J. Q. Brown, has been ver successfully used at the rooms of the State Board of Trade at San Fra cisco:

"Put thirty gallons of water into a forty-gallon barrel; float on top

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a tin pan, in which put a portion of 25 cents' worth of sulphur. lphur on fire and cover tightly until the fire goes out; renew ur until the whole is consumed, opening the barrel for renewal veen doses."

his mode of proceeding is somewhat wasteful of sulphur, and mproved upon by cellarman, yet it is so simple, and sulphur p, that it may well be recommended for use on the farm.

ately the use of *mercuric bichloride*, or *corrosive sublimate*, for se has been brought prominently forward by Prof. P. Pichi, oratory for botany and vegetable pathology in the Royal Viti- chool of Conegliano, Italy. In an article published in the April f the official journal of that school, Professor Pichi discusses ements for the preservation, especially of collections of grapes, he most difficult of all. He states, that after experimental ll the usual preservative solutions, such as alcohol of various and of watery solutions of salicylic, boracic, and other acids, of copper, he finally made trials with solutions of corrosive ranging from 1 to 4 *pro mille* in strength. After two months ill in perfect preservation, both as to color, form, and size, and remained firmly attached to their stems. After five months, n the 1 *pro mille* solution was in a decidedly unsatisfactory and after the first year, unfit for study; while those in the lution were in good condition, but the fluids were of a slightly nge, particularly in the 2 *pro mille* solution. After four or five re, this difference against the weaker solutions was still more d, and it was evident that 3 *pro mille* is the least strength com- th good conservation. A second series of experiments con- s, and pointed to a solution of 4 *pro mille* as probably the best. conclusions are stated as follows:

all that I have reported I believe that I am able to conclude bunches can be best preserved for collections by keeping ersed in a solution of corrosive sublimate, taking care to wash oughly beforehand with water. At first we will use a solution *ille*, and after some time we replace this with a solution at 4 About the end of the second year we will renew the solution, ll thus have assured their preservation for a number of years, ut a trifling expense."

nor finally calls attention to the poisonous nature of the pre- id, which is, however, the same as in pathological laboratories infection of hands and instruments after use in anatomical

ngth above referred to as the best is equal to *half an ounce of ublimate to a gallon of water*. Nothing is said by Professor rding the addition of glycerine or anything else to correct the the solution; and it is possible that the hardening of the s, caused by the action of the sublimate, renders such addi- essary.

is would certainly be both the most perfect and the cheapest satisfactory preservation thus far found, the possibility of mistakes for such specimens of ordinary "put-up" fruit alone Its merits, with respect to other fruits than grapes, are now at this station, and will be fully tested during the coming all available fruits.

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The solution should properly be made with *distilled* water. Whe this is not available, other water may be used—preferably that from th larger streams; but (particularly in the case of well water) it shoul first be boiled and allowed to clear by settling, before dissolving th sublimate. Even then a whitish or grayish turbidity and sediment wil usually form after awhile; this should be allowed to settle fully befor putting the fluid over the fruit. It would be well to label all such frui jars "POISON," for the sake of safety. No metal must come in contac with the sublimate solution, as it would be quickly decomposed.

[Experience had since the publication of the above article suggest the following points:

The solution of corrosive sublimate, prepared as above prescribed, an with the proper addition of glycerine to prevent shrinking or burstin of the fruit, insures a very perfect preservation of the form and size the fruit. The color is not extracted, but is marred materially by deposit of a whitish powder (calomel) on the surface of the berrie giving a ghastly appearance. This deposit is not mentioned by Pr fessor Pichi, perhaps because it is really of little consequence in th preservation of specimens for instruction; but few would desire to e hibit their fruit in such unattractive exterior guise. In the case of th solution, the exclusion of air appears to make no difference, so long evaporation is prevented.

The use of the solution of sulphurous gas, with a proper addition glycerine, and with exclusion of air (to prevent the escape of the su phurous gas), therefore in glass-stoppered or otherwise well sealed jar is the next best preservative so far as form is concerned, but it bleach all colors very sensibly in the course of a few months, and while th fruit is not thus made to look as ghastly as in the case of the mercuri solution, white cherries, plums, and strawberries, and oranges of a ligh lemon yellow, are not very natural-looking; yet, if the fruit has not be kept very long, this solution supplies an easy mode of preserving intact, if not with its full color.

The solution of salicylic acid, or salicylate of soda prepared as abo indicated, and kept from access of air by tight sealing, acts very we and does not bleach the colors; but in the case of deeply colored fruit such as cherries and blackberries, the color is extracted and imparte to the fluid in the ratio of its bulk to that of the fruit. There is thu at least, an indication left of the intensity and tint of the original colo which in the use of the sulphurous solution is lost entirely, and in th of the mercurial one veiled by the film of calomel.

Experience also suggests that inasmuch as all fruits, when they a to be preserved for exhibition, are gathered before full maturity in ord that they may not be too soft for handling and transportation, ther fore the full amount of sugar given by the analyses quoted in the abo table is not yet present as it was determined in fully ripe fruit. Henc in some cases, the full amount of glycerine prescribed caused contra tion, from which the fruit (especially cherries) did not recover full It would seem advisable to reduce the above figures to two thirds even to one half, according to the stage of ripeness at which the fru has been gathered.

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nents with the bisulphite of soda ("California Fruit Salt") are s and may yield more satisfactory results than the free sul- cid of the solution prepared as above. The use of this salt ve the advantage that the strength of the solution could be gauged by the weight of the salt used to each gallon of

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THE SULPHURING OF DRIED FRUITS.

By E. W. Hilgard.

(*Experiment Station Bulletin No. 86.*)

ter's views on the above subject have been so often expressed etings of fruit growers, and in print before the general public, ght seem uncalled-for to reiterate their formal expression in . Yet the frequent requests, both written and verbal, for such ns seem to render it the briefest mode of disposing of the sub- more, as the only radical solution of the question lies in its re and more fully understood by consumers (to whom these are equally addressed) who now sacrifice good flavor and ness to mere appearance.

phuring of dried fruit has two chief objects. One, and that rally kept in view, is the brightening of color, which always particularly in sliced fruit, in whatever way it may be dried, e of color being due to the action of the air (oxygen) upon sily changeable substances contained in *all* fruits. This dark- stly to a light brown) is a practically inevitable result of *y* fruit in contact with air, whether in sunshine or by artificial should be looked for by every consumer as the natural mark est, unmanipulated article.

ond object sought to be attained by sulphuring is to render ecure from the attacks of insects, whether by rendering its palatable before the eggs are laid, or by killing eggs laid dur- rying, that might subsequently hatch in the packages. The ct involves, of course, the sulphuring of the *dried* fruit; while r is, to a greater or less extent, attained by sulphuring *before*

cts of sulphurous acid (the gas, not the visible fumes given urning sulphur) as a disinfectant and bleaching agent, are understood. The gas is absorbed by the moisture of the fruit, nt dependent upon the time of exposure, its fresh or dried , and the amount of sulphur used. When freshly sliced fruit red *for a short time*, the gas penetrates only "skin-deep;" and fruit is afterward dried, whether in the sun or drier, most of capes and few persons would note the difference in taste pro- reby. Insects, nevertheless, are to a material extent deterred hing such fruit.

en the latter is dried and *then* thoroughly sulphured, as is too y done, the effect is much more serious. The gas then pene- entire spongy mass, bleaching it, so that carelessly dried fruit, to be marketable, can thus be made to appear more or less to the eye. Not, however, to the nostrils or to the taste, for color the *flavor* has also suffered correspondingly; and upon

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opening a package of such fruit, instead of the natural aroma, ther appears the flavor familiar to those who visit a chemical laboratory or acid manufactory.

The consumer then has reason to object to dry-sulphured fruit o two counts, either of which is sufficient to condemn the practice. On is that dirty, ill-prepared, or damaged fruit may thus be imposed upo him for good quality; the other, that the natural flavor of the fruit i either seriously impaired or sometimes almost completely destroyed, an (as will be shown) its acidity greatly increased.

There is another and very serious count in the indictment, namely that such fruit is unhealthy because containing an antiseptic tha impedes digestion, and, while the fruit is relatively fresh, causes head aches, just as will sulphured wine. After some time the "sulphurous" acid originally introduced becomes converted into "sulphuric" acid, condiment that few will desire to consume in their daily food. Th precise extent to which this may be present is shown in the subjoine analyses, respectively of apricots sulphured before, and of "silve prunes" sulphured after drying, as found in the market:

	Total Acidity.* Per Cent.	Sulphuric Acid (SO_3) Per Cent.
Non-sulphured apricots		.067 (combined
Sulphured apricots		.232 (mostly free
Non-sulphured prunes	.321	.056 (combined
Sulphured prunes	.544	.346 (mostly free

In considering the above results, it should be understood that th sulphuric acid, given as contained in the unsulphured fruit, is presen in the form of "neutral salts," such as occur in the ash of all vegetabl products; while that which is added in sulphuring exists in the form o free acid.

It will be seen that in the case of the apricots the increase was t the extent of about twice and a half the amount originally present although these were reported to have been sulphured only *before* (mor probably *during*) drying. Their lack of natural flavor and pungen acid taste at once revealed the effects of sulphuring.

In the prunes which had been sulphured *after* drying, the effect wa much more striking. Here the increase was over *six* times the natura contents. The total amount added by sulphuring amounted to nearly a third of 1 per cent, and the free sulphuric acid in the dried frui amounts to .22 per cent, which is equivalent to about twenty-five grain of commercial oil of vitriol per pound.

In addition to rendering the fruit unpalatably acid, it has been ren dered obnoxious both to the digestive organs and to the teeth. No on could habitually consume such fruit without feeling the effects of such an amount of mineral acid, introduced into his food purely for the grati fication of the eye with an unnatural tint.

But so long as the public and its agents, the dealers, continue willin to pay from 30 to 50 per cent more for the whitened sepulchres offere them in the shape of sulphured fruit, than for that which retains, wit its natural flavor and sweetness, the natural tint of dried fruit, and wit it the marks of careful or careless treatment, so long will the produce

* Expressed in terms of sulphuric acid.

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to supply the demand for the doctored article; unless, indeed, hould intervene, as has been done in most European countries. e sale of sulphured fruit is simply forbidden as injurious to alth, and as coming under suspicion of having been "doctored an inferior article, with fraudulent intent.

therefore, it is asked what I think is the proper policy to be n this respect, by a region which this year will, for the first e into the dried-fruit market, I reply that I think that the time to make a step forward and try to put upon the market a first cle of "unsulphured dried fruit," with the express statement that it *is* unsulphured and retains the natural sweetness and California fruit, instead of being reduced to a common level worst products of any other country. For it is certain that the reen dried apples and pears now sold at high prices in our ores, might just as well have been grown anywhere from Nor- e Mediterranean, for aught they teach of the quality of our

lowing suggestions are offered to those who are willing to prac- uring to a moderate degree only, and with some regard to the ion of the fruits' palatableness:

uantities of sulphur introduced at once into the drier or sul- ox will tend to cause a deposit of sulphur, in substance, on the the fruit, adding its flavor to that of the acid, which alone is he less sulphur is put in at one time, and the more air admitted, here will be of the visible fumes that carry the sulphur up into It is best to let the sulphur catch fire *all over* before putting box at all.

atever sulphuring you must do be done *before* drying, as in that nly will the drying process itself drive off a great deal of the s acid and prevent it from penetrating the whole, but the flavor erior will penetrate outward and measurably do away with the odor that will otherwise pervade the fruit package.

sightly and appetizing cinnamon-brown tint for sliced apples may be secured by dipping, for a few minutes, the freshly- es, contained in a properly shaped basket (of galvanized wire), into a solution of salt containing not less than two ounces lons of water. This prevents any spotting where the fruit has ned. Instead of the salt, a similar solution of the bisulphites lime may be used, which effect a slight external bleaching jury to the flavor of the fruit.

t not least, let us try to gradually educate the public taste up nt of preferring in this matter the substance to the shadow, and healthy, brown, high-flavored dried fruit to the sickly-tinted, tainted product of the sulphur box.

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VI. FERTILIZERS, ETC.

THE USE OF FERTILIZERS IN CALIFORNIA.

By E. W. Hilgard.

(*Experiment Station Bulletin No. 88; October 6, 1890.*)

The fortieth anniversary of the admission of California into the Unio reminds us that she has ceased to be a stripling. With this advance i dignity comes the inference that however fertile her soils, it is to l expected that those long occupied, or heavily cropped, will now requi serious care in order to keep up or restore production. That this really so is proved by the rapidly increasing correspondence on the sul ject that is addressed to this Station; and to avoid the unnecessa rehearsal of general statements in each individual case, it seems desir ble to put in print for general information what can be stated in a ge eral way on this subject. Of course, many individual cases will sti require special consideration on account of peculiar conditions of so or location; for in a great many instances, the failure to produce sati factory crops is not at all due to soil-exhaustion, but to improper phy ical conditions of the subsoil, unsuitable cultivation or irrigation, alka etc. The fact that orchards and vineyards form costly investments much greater permanence than the annual crops that occupy the va majority of the cultivated land east of the Rocky Mountains, and th high returns so often realized from them, has brought the manure que tion forward here much earlier than has usually been the case in th United States; and happily, the silly adage that "manuring is t costly, and will never pay," which has long kept agriculture on th down grade elsewhere, has never had a serious foothold in Californi The sovereign truth that nothing pays worse than poor crops up large areas of which the cultivation costs just as much as if it we yielding high returns, is quite generally appreciated here. Cultivati too much land poorly, and getting poor returns both as to quantity a quality, has been the bane of farmers all over the East, and has doub less done at least as much toward "agricultural depression" as all oth causes combined.

But whether fertilization will pay or not clearly depends direct upon the particular requirements of each soil. Unlike Europe, whe long cropping has reduced all soils alike to a condition when th require an "all around" fertilizer, the soils of California have most had a *one-sided wear* from the constant succession of one and the sa crop. In orchards and vineyards this state of things is unavoidab since they are expected to last twenty to forty years without renew or possibility of rotation of crops. It is this one-sided wear, insepa ble from the chief horticultural industries of the State, that requi special attention at this time; for it is clear that to apply "complet fertilizers in these cases, would be to pay out a portion of their c uselessly, since nothing can be gained by adding to the soil more of t ingredients that are already abundantly present in available form.

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er to fertilize intelligently we must know, first of all, what
ts are chiefly drawn upon by the crop sold off the land; secondly,
know which of these ingredients are so abundantly present in
or irrigation water, as the case may be) to render their replace-
ecessary for the present at least.

bjoined table gives some insight into the amounts removed by
y some of the chief fruit crops, of nitrogen, potash, phosphoric
lime; these being, according to all experience, the only ones
the replacement need ordinarily be considered in fertilization.
ounts are expressed both with reference to one thousand pounds
ruit, and to what, according to our best information, may be
to be a "fair crop" per acre. The latter figure is, of course,
great variations and differences of opinion; but, by the aid of
ithmetic, each one can calculate for himself the data suitable
n case or views. The crop assumed in the case of oranges is
per acre of fifteen-year-old trees; that of grapes is intended to
a mean between upland and lowlands.

*Quantities of Soil Ingredients Withdrawn by Various Fruit Crops.**

Fresh Fruit.	Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
00 pounds	8.8	5.00	1.52	1.70
0,000 pounds per acre	88.0	50.00	15.20	17.00
000 pounds	6.1	2.78	.67	2.69
0,000 pounds per acre	122.0	55.60	13.40	53.80
pounds	3.3	1.80	.50	.60
0,000 pounds per acre	66.0	36.00	10.00	12.00
0 pounds	2.9	1.72	.44	4.20
0,000 pounds per acre	87.0	51.60	13.20	167.70
00 pounds	2.2	.80	.30	.60
0,000 pounds per acre	44.0	16.00	6.00	12.00

be seen that for equal weights of these fruits, *grapes* take from
y far the largest amount of mineral matter, of which nearly
s is potash; they also carry off the largest amount of phosphoric
r seedless grapes the latter item would, however, be considerably

the drain of total mineral matter from the soil stands the
also draws heavily on the potash, and also upon the nitrogen
l, but less than the grape upon phosphoric acid; this independ-
he seeds, the analysis having been referred to seedless fruit;
ing (seedling) fruit would presumably draw more heavily both
horic acid and nitrogen.†

come next as regards total mineral matter, but draw quite
nitrogen.

(including prunes) are conspicuous chiefly for their heavy
on the nitrogen of the soil, greatly exceeding in that respect the
r equal weights, and enormously for an (assumed) average crop.
fference between *apples* and *pears* in respect to soil-exhaustion

lyses of ashes here given are mostly those of European chemists, generally
representing averages. California-grown fruits will be investigated at this
coming season for this purpose.
alyses of California oranges seem to show no material difference between seed-
l seedless fruit.

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for an equal weight of fruit is quite striking, the amount of potash in apples being less than half, the phosphoric acid only a trifle over half as much as in the pear; while nitrogen is equal in both, and quite low as compared with the orange, which has over four times as much, and must therefore be accounted relatively much more nourishing to man as well as more exhausting to the soil.

While the data given above, in relation to the "outgo" of soil ingredients, through the harvesting of the several fruits, may be considered as holding good, practically, in all countries and on all soils, the vast differences in the nature and composition of *different soils* introduce an element of uncertainty as to the need of returning to every soil the full amount of the outgoing ingredients. Few soils are about evenly constituted with respect to the four important plant-food substances. There is, in most cases, one or several of these present in superabundance, so that to replace the small amount carried off by the crop would be as useless as "carrying coals to Newcastle;" at least for the present. *The analysis of soils and irrigation waters is necessary to gain information on these points.*

As regards waters, the information so obtained is positive and unimpeachable. Whatever is dissolved in the irrigation water is absolutely available to vegetation, and the amount annually so conveyed to the soil is capable of close calculation on the basis of the current practice of each irrigation district. If the amount of any substance so given to the soil approximates to, or exceeds the amount withdrawn by crops, it is quite certain that no money need be expended in the purchase of that particular substance as a fertilizer.

As regards soils, the indications given by chemical analysis are not so definite, because the acids used in the laboratory are more powerful than those at the command of the roots of plants; although some of the latter (*e. g.*, oxalic acid, that of sorrel, rhubarb, etc.) approximate closely to the same solvent power. Here experience must be our main guide and this has shown that, practically, soils containing (by the results of analysis) more than a certain percentage of a given substance, may be considered as abundantly supplied with the same; while if the percentage so indicated falls below a certain other point, such ingredient may be considered as being deficient. The crucial test in either case is the experimental use of that substance as a fertilizer on the soil in question when it fails to produce a definite, favorable result, it may be considered that the native supply is sufficient, and *vice versa*.

It is obvious that in order to secure to the farmer this saving of the purchase of superfluous fertilizing ingredients, a comprehensive system of investigation of soils and waters is necessary. This has been from the outset the central thread of the work of this Station; the object being to obtain, as quickly as possible, the facts necessary for the compilation of a soil map of the State. For want of funds for field work and too limited a force for laboratory work, this fundamental plan has been carried out only to a limited extent, and chiefly in certain regions where considerable interest in agricultural improvement was manifested. We are not, therefore, as yet prepared to give information as to the entire State; and unless some special provision is made it will be long before this can be the case. But, so far as the work has gone, the following points may be considered as practically settled:

1. From climatic, as well as geological causes, nearly all the soils of

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may be considered as abundantly supplied with *lime*. The
ptions occur in the higher portions of the foothills, where the
high, and summer rains occur. In *all* the valley soils lime
nt; and liming is, therefore, not among the means of improve-
ally to be thought of in California. This applies to the use of
and ground limestones; not necessarily to the use of marls,
ually contain other ingredients besides lime, to render their use
where it can be done with little cost.

ost the same that is stated above of lime may be said of *potash*.
majority of soils in this State, more especially all valley soils,
utely *all* soils in which there is the least manifestation of alkali,
n abundance of available potash for all agricultural purposes;
o that dissolved potash salts frequently circulate in the soil
Most irrigation waters furnish an additional supply, sometimes
itself to make up for all that the crops take away. Outside
ny belts of the Sierra and of the northwest coast, therefore,
on of potash in fertilization must, in general, be considered in
of "carrying coals to Newcastle"—superfluous and unprofitable
sent time; and farmers should object to paying for the potash
rcial fertilizers (put there under the Eastern idea of making
lete" fertilizer), because the investment will pay them no
They should demand for their money the ingredients that
hem for their use in this State, regardless of what may pay

cases in which at present the use of potash *will* pay are those
culture in vegetable gardens and berry patches, where crops
continuously and successively throughout the season. Here
ht upon the soil ingredients is so heavy that within a few years
e current replacement.

hosphoric acid, an ingredient so important that even in Europe
nning to be claimed as the practical measure of fertility,
has shown an almost universal *scarcity* in the soils of this
ays excepting the alkali soils, in which it, or its compounds,
circulate in proportionally large amounts. Phosphoric acid
the substances to be first suspected of exhaustion in the non-
oils of California; it is therefore an ingredient that should be
t in *all* compound commercial fertilizers, and which will be
'pay" in most cases of decreasing production.

the fourth of the critical soil and plant ingredients, *nitrogen*,
ry measure in soils is the vegetable mould or humus, the
of which is generally manifested, and outside of "red" soils is
asured, by the more or less blackish tint when wetted. From
auses, humus is rarely abundant in the upland soils of the
very generally its amounts may be said to be small. This is
true of the mesa soils of the South—those best adapted to the
the citrus fruits—and hence it is reasonable to suppose that
nitrogen will be among the first things to be apprehended when
shrinks in size and production falls, on these soils.

ere stable manure is the ordinary source of this as well as of
substances when required only in moderate amounts; but for
sons stable manure is less available in the dry climate of Cali-
an elsewhere. It is produced only in small quantity in horti-
communities; and when put in the soil it is long in decaying

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and becoming effective. It should for our climates be systematically "cured" in the manure-pile before being used—a point of vantage which explains, in part, the good effect of sheep corral manure.

By far the most convenient, and at present certainly the cheapest and most available source of nitrogen at command of the farmer, is *Chile saltpeter*, which contains about 16 per cent of nitrogen in its most effective form. From one hundred and fifty to two hundred pounds per acre is the usual dose; more than this will not be used by the crop plants in one season, and a surplus is likely to be washed out of the soil by the winter rains. Moreover, an excessive application might result in too much wood and too little fruit, and that fruit of a sappy, flavorless character, though of large size.

Sulphate of ammonia is the other most available source of nitrogen obtainable in commerce. A good commercial article contains 20 per cent and over of nitrogen. It does not, however, act quite as rapidly as the Chile saltpeter.

To the citrus growers, then, who at present seem to be most concerned about the fertilizer question, I would say that, well-cured stable and sheep corral manure apart, their best resort at present is to the commercial phosphates and superphosphates of high and honest grade, mixed either by themselves or by the manufacturer, with a proper proportion of Chile saltpeter or ammonia sulphate, and generally no potash whatever.

In order to cover approximately the ground of the questions most commonly propounded in our correspondence on the subject of fertilizers, the following points are briefly stated:

This Station has no direct or definite knowledge of the quality or "trueness to name" of any of the commercial fertilizers now sold in this State. Analyses of mere samples sent by the manufacturers or others prove little or nothing, so long as no regular "fertilizer control" is established by State authority. That this should be done as soon as possible, in the interest of both the users and honest manufacturers of fertilizers, is manifest; and nearly all the older States have found this regulation of the fertilizer trade necessary long ago. At present this Station declines to analyze, and certify to the composition of fertilizer samples, except in cases of suspected fraud, for the reason that such samples prove nothing as to the general quality of the material put on the market, and their analyses have been used in advertising as though offering a kind of guarantee or recommendation on the part of the Director. The latter disclaims pointedly any such responsibility, and does not authorize the use of his name in connection with any fertilizer advertised. He has, however, no reason to question the *bona fide* character of the several fertilizers manufactured in this State. That in individual cases disappointment must often occur, is natural from the causes stated above, and proves nothing against the honest composition of the goods. In this, as in other cases, the right thing may be put in the wrong place. The useless addition of considerable potash is the objection lying against several of the brands in the market.

Farmers should be willing to pay a good price for a high-grade fertilizer, especially in the case of superphosphates. The only consequence of insisting on too low a price is that the manufacturer, in self-defense adds to the active matters, enough of some cheap, inert material to be able to afford the lower rate; the result being that the farmer pays

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o say the least, on "dirt," which he might as well put in on if so inclined. "Spent refinery charcoal" in coarse grain is unprofitable an investment as a farmer can well make. He e willing to pay enough to justify the manufacturer in reduc- grain of it to the soluble form by the use of enough sulphuric is not advisable for any one to attempt to do this at home.

ard to the use of *bones*, it may be said that any one may, with uble, use all the bones accumulating about a homestead in three ways:

es put into a *well kept* (moistened) *manure-pile* will themselves decay and disappear, enriching the manure to that extent.

bones may be bodily *buried in the soil* around the trees; if a sufficient depth, beyond the reach of the summer's heat and the rootlets will cluster around each piece, and in the course of ars consume it entirely. But it will not do to have these root- broken up by cultivation every season.

es may be packed in moist wood ashes, best mixed with a cklime, the mass kept moist but never dripping. In a few he hardest bones will be reduced to a fine mush, which is as as superphosphate. "Concentrated lye" and soil may be used f ashes. In this process the *nitrogen* of the bones is lost, going form of ammonia, the odor of which is very perceptible in the l.

ither of these processes should the bones be *burnt*. The burn- nes is an unqualified detriment to their effectiveness, which be undone by the use of sulphuric acid.

es *steamed* for three or four hours in a boiler under a pressure five to forty pounds can, after drying, be readily crushed in an barley-crushing mill, and thus be rendered more convenient Practically, very little of the nitrogen (glue) of the bones need ost. Very good *bone-meal* is found in the market at reasonable

formation concerning the value and proper use of *land plaster* n (also one of the inquiries continually made), I refer to pages 145 of the "*Report on the Experiment Stations*," lately issued, ll be mailed free to any one desiring it. It may here simply be at while gypsum is not a general fertilizer like the phosphates ates, for the simple reason that it does not contain, and there- not supply, the plant-food substances of which the withdrawal causes sterility: yet its uses, especially in the irrigated regions lkali soil, are so many and so important that it should be very sed so soon as a reasonably cheap supply can be obtained.

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ANALYSES OF FERTILIZERS.

Fish guano; sample sent by Messrs. Allen & Lewis, San Francisco; manufactured by the Alaska Oil and Fertilizer Company, Killisnoo, Alaska.

The air-dried substance was found, on analysis, to contain:

Moisture	12.9
Nitrogen, as ammonia (ready formed)	.62
Organic	10.83
Total	11.4
Calculated as ammonia	13.9
Potash	.8
Phosphoric acid, insoluble	.80
Soluble	1.91
Reverted	3.29
Total	6.0
Phosphoric acid available (reverted and soluble)	5.2

The nitrogen in the above, while in fair amount, is mostly in th form of organic matter, which needs to undergo decomposition befor being available for plant use.

The comparatively large percentage of available phosphoric acid add value to the guano as a fertilizer, while, on the other hand, the presenc of a larger amount of potash will not be needed upon the lands of thi State, which already are well supplied. Altogether, this sample com pares very favorably with the fish-scrap fertilizers usually put upon th market elsewhere in the country.

Dry "hog tankage" fertilizer; sent by Messrs. Frost & Burgess, River side, with request for opinion as to its fitness as a fertilizer for nursery stock. The analysis shows that the sample contains 7.54 per cent o nitrogen, equal to 9.15 per cent of *ammonia.* The proportion of othe ingredients was not determined. This is evidently a bona fide article and will be of high efficacy as a furnisher of nitrogen in place of Chil saltpeter or ammonia sulphate.

Sulphur refuse, from the sulphur works near Shell Mound Station Alameda County; sent by the Messrs. Sherwood, San Francisco.

"This refuse is from the reduction of sulphur ores, and is compose of sand, loam, lava, ashes, etc. Will it make a good fertilizer?"

An analysis of the sample shows the presence of the following:

Insoluble matter	46.0
Potash	
Soda	
Lime	
Magnesia	
Peroxide of iron and alumina	1.
Phosphoric acid	
Sulphuric acid	2.
Sulphur	37.
Organic matter and water	12.
Total	100.0

The amounts of the important elements of plant-food (potash an phosphoric acid) present in the sample are no more than are found i ordinary soils; there is very little lime or magnesia; while on the othe hand, the enormous amount of sulphur and sulphuric acid would be positive injury to any soil.

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, *from Sophia Island;* sent by Messrs. Crawford & Co., San
o; the analysis to be compared with those of other samples of
made by other chemists.
made at the University of California Experiment Station.
made by Messrs. Thomas Price & Son, San Francisco.
made by Mr. J. A. Pond, public assayer at Auckland, New

resume that the sample of the article we now send you com-
orably with the sample that the above named parties assayed."
r-dried substance contains:

	No. 1.		No. 2.	No. 3.
		9.37	5.90	5.86
ammonia (ready formed)	.08			
nitrates	.48			
rganic	.66			
rogen found	1.22			
lculated as ammonia		1.50	2.30	
		.08		
acid, soluble	.27			
acid, reverted	4.28			
ilable	4.55			
acid, insoluble	26.51		24.61	
horic acid, available and insoluble		30.06	24.61	31.26
le matter (organic and carbonic acid, etc.)		26.40	32.25	52.44
tter (not included above)			34.41	

ove analysis, made only with a view of showing what are the
anurial ingredients of this guano, shows quite material differ-
composition, and therefore in value, from the samples of which
have been made by Messrs. Pond and Price. We find con-
more phosphoric acid and less nitrogen and organic matter
Price; while in phosphoric acid we agree nearly with Pond.
ng the large proportions of insoluble phosphoric acid present,
of some sulphuric acid is advisable, to give it better value,
it will do much good even as it is. Its particular adaptation
for the orange-growing districts of South California, where
a is needed, but chiefly phosphoric acid and a moderate amount
en.

THE FERTILIZING VALUE OF GREASEWOOD.

By E. W. Hilgard.

(*University Experiment Station Bulletin No. 94.*)

ntity of the dry brush of the greasewood plant (*Sarcobatus ver-*
) was furnished by Geo. W. Raymond, of Miramonte, Kern
the object being to determine whether or not it would pay to
plant, or its ash, as a return to the soil, or in making composts
al purposes of fertilization.
ble below shows the result as obtained by Mr. Jaffa, alongside
h analyses of some other well known plants, for comparison.

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Table Showing Ash Composition of Greasewood Compared with Other Plants.

	Grease-wood.	Samphire.	Seaweed.		Cabbage.	Timoth Hay.
			Fucus vesiculosus.	Laminaria digitata.		
Silica	11.81	.....	1.7	1.6	1.2	3
Potash	18.53	2.6	14.5	22.4	48.6	2
Soda	39.45	36.4	24.0	24.1	3.9	
Lime	1.36	.....	13.9	11.9	15.3	
Magnesia	1.09	.....	9.5	7.4	3.3	
Peroxide of iron and alumina	7.06	.....	1.1	.6	.....	.....
Phosphoric acid	3.51	.....	3.1	2.6	15.8	1
Sulphuric acid	4.93	.....	24.0	13.3	8.5	
Chlorine	15.30	.....	10.1	17.2	2.5	
	103.04	.....	.....	.....	.....	.....
Less excess of oxygen due to chlorine	3.25	.....	.....	.....	.....	.....
Total	99.97	.....	.....	.....	.....	.....
Ash percentage of plant	12.03	.....	14.4	18.6	10.8	

It will be noted that of all the plants here shown, among which a three (samphire, or "salt grass," and the two seaweeds) presumed contain unusually large percentages of soda, the greasewood shows t largest amount of sodium salts, nearly 40 per cent of the ash being so out of which over 25 per cent of common salt and nearly 8 per ce of Glauber's salt are formed. There remains out of the total amou shown in the analysis 23 per cent that will go toward forming carbon of soda, if returned to the soil, increasing its weight to about 39. T means that out of one hundred pounds of greasewood ash, seventy-t pounds would be "alkali" of the usual composition of "black alka which would, at the very least, be of no use to any soil; while to th already charged with alkali it would be decidedly detrimental, as addi so much to the evil already existing.

It is true that there are 18 per cent of potash and 3½ per cent phosphoric acid to be placed to the credit of the ash, as available a valuable plant-food. But as potash is usually abundant already in t soils upon which the greasewood grows, this would hardly outweigh t disadvantage of the alkali in the same soils. Practically the 3½ p cent of phosphoric acid alone is to be written to the credit of the grea wood ash where it would usually be convenient to apply it, against t disadvantage of a returning of three fourths of the whole ash in t useless or detrimental form of "alkali."

The question still remains, how much of the other important fertil ing element, nitrogen, would be supplied by the *fresh* plant. This h not as yet been determined; when it is, it may turn out that on we drained soils not too rich in alkali the use of fresh or dried (but not burnt) greasewood brush would be advantageous.

On the other hand, it may be asked whether in clearing greasewo land it would be an advantage to remove the brush, so as to dimini the alkali, as is done when beets are planted in saline soils.

The fresh plant, including stem and leaves, may be estimated to co tain about 75 per cent of water. A ton of the fresh brush would th contain five hundred pounds of dry matter, of which sixty pou

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ash; and of this ash about forty-five pounds would be true, alkali."

, the ground were so thickly overgrown with the greasewood ish about ten tons of brush per acre, to remove that brush equivalent to taking away something like a quarter of a ton This is not an insignificant amount in soils liable to injury excess of salts; and if the process were repeated several times ewood would serve, like the beet, to remove a very notable n of the total alkali salts present in the soil, just as does the of samphire in reclaiming salt-marsh lands. On the other hand, greasewood growth only scattering, its removal would serve no y important object.

rison with Other Crops.—Comparing greasewood with the other nes in the table, it will be seen that while it does not agree ith any of these, it approaches the seaweeds more closely than hire in its contents of potash and phosphoric acid. Seaweed used for preparing fertilizing composts in countries where sum- s prevail, and usually on the sandy seashore soils, through e excess of saline matters (sodium salts) is readily washed into ainage, and consequently does not stay to increase the salts in s would be the case in our arid climates. It will be noted that , supply considerable potash, much needed in rainy countries, a small proportion of phosphoric acid, upon which the food e plants draw so heavily, as is seen in the annexed analyses of of cabbage and timothy hay. Phosphatic fertilizers are, there- ful in connection with the use of seaweed (and greasewood) in order to supply the demands of the common culture plants.

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II.

REPORTS

ON

RE WORK AT THE EXPERIMENT STATIONS.

Central Station; Alameda County.
Foothill Station; Amador County.
Southern Coast Range Station; San Luis Obispo County.
San Joaquin Valley Station; Tulare County.
South California Station; Los Angeles County.

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ON CULTURE WORK AT THE SEVERAL EXPERIMENT STATIONS.

ENTRAL EXPERIMENT STATION.

Berkeley, Alameda County.

EPORT ON FIELD WORK AT CENTRAL STATION.

By Edward J. Wickson.

ture work at the Central Station has been prosecuted under gent supervision of Captain E. Kellner, as foreman. His e resulted in more economical and efficient management and

l outline of the work carried on during the year, including a special features to which fuller allusion is made in other portis report, may be sketched as follows:

work consisted in the main of sowing the whole cereal collection continuation of the experiments with the Hessian fly, and pose of securing fresh seed of some varieties which had not en reproduced. The plots adjoining the Economic Garden he western entrance to the station grounds occupied a rich d underdrained with tile the previous year, and thus rendered or this purpose. The benefit derived from the tiling was very It rendered early sowing possible where, before draining, as boggy until late in the spring, because of abundant seepage djacent hillside. The wheat plots during the whole growing e notably fine in appearance and attracted much attention ors. On the main field of the station grounds there were s of other cereals than wheat, and large plots of varieties desired for seed-distribution supplies for the coming winter. y was produced on other portions of the main field to sustain team during the year.

and Vineyard.—The old vineyard plot adjacent to the greenich has been maintained several years longer than otherwise for the special purpose of observation and experimentation hylloxera, was cleared out during the spring of 1890, and the secured was devoted to the extension of the olive plantation, made necessary because of the large accessions made to our ieties by direct importation from Italy and France, and by from other importers. These trees have made very satisfach.

ular-shaped piece of ground adjoining the Economic Garden, h eucalyptus trees were cut several years ago, was cleared of enched deeply, and planted to resistant grape varieties, for re was not sufficient space in the Economic Garden. This eyard has been neatly trellised with a strong post-and-wire

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trellis, and offers excellent opportunity for growth with long cane which most of these varieties require for fruiting. It prepares the wa also for comparative experiments in long and short pruning of the sam varieties; also, to secure more wood for cuttings for outlying statio and for distribution.

Our standard orchard of deciduous fruit trees has been maintained i the same manner as in previous years, and extended by the introductio of many new varieties, both of local and distant origin. The aprico collection has been thus extended, extra space being secured by rootin up a portion of the later-ripening peach and nectarine varieties, f which this location is not suited.

The underdrainage of the orchards, to which allusion has been mad in previous reports, has continued to yield satisfactory results. Th surplus water is quickly removed from portions which were previousl so boggy during the winter that cultivation could not be pursued at th proper time. Since the drainage, the orchard area is nearly uniform i its moisture conditions, and can be freely worked at desirable times.

Garden and Nursery.—The Garden of Economic Plants has been co tinued upon its former plan, and through other provision for a portio of the grape collection and for purely botanical growths, more spa has been secured for the extension of other features of the collection The growth of many exotics in the garden has made them special interesting and attractive, and furnishes data for many allusions other portions of this report. The same is true of the results attain with grasses and forage plants, reported upon elsewhere. Each ye the garden, by its command of popular interest and demonstration the adaptation of plants from distant countries to this climate, is mo fully realizing the purposes had in view at its establishment.

The needs of the Department of Botany are being met for the prese by the establishment of a botanic garden on another portion of th station grounds. It has been laid off with suitable plots and walks, an is being progressively planted under the direction of the Associa Professor of Botany.

The old nursery ground adjacent to the greenhouses being too sma to meet the growing demand for propagation for outlying culture statio and for distribution, a new piece of land in the northeast corner of th main field was plowed, subsoiled, and laid off for nursery work. A pa of the space was given to the multiplication of new Italian and Frenc grape varieties, mentioned elsewhere, to the propagation of deciduo fruit trees, and to other growths needed for distribution. The site is we suited for the purpose, except in the lack of water supply, which can secured later.

Propagating Houses.—The re-painting and glazing of the old prop gating houses has extended their period of usefulness somewhat, but th fact of their insufficiency for the present work of the station is more an more clear. Not only is it impossible to keep up with the demand f propagation under glass, but, as has been stated in earlier reports, val able plants are being continually sacrificed because their growth enda gers the low, insecure roofs under which they expand. There is serious needed proper greenhouse accommodations. Many plants, notably th palms, become interesting and valuable as they attain size, and yet ju at this point we are obliged to throw them out. There is, fortunatel reason to expect that a remedy for this deplorable state of affairs w

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rovided in the form of a plant house, for which provision has
e from the General Fund.
house has been constructed sixteen and one half by twenty and
eet, with a height of eight feet eight inches. This is strongly
edwood frame, with battens instead of lath, which gives the
promise of long usefulness.
opagation during the year has been chiefly in the line of
plants for trial and distribution, as heretofore. With increased
lation we hope to do something more to interest the planter for
rnment.
ums.—The hillside arboretums on the eastern boundaries of
rsity grounds have been given due attention, and the results
satisfactory, considering the difficulties of the arid situation.
s of the heavy winter of 1890 were obliterated by grading;
were cleared and repaired, and the arboretums made more
Additional plantings included English oaks and Monterey
The oaks have done moderately well.
etum on the west side of the grounds has been improved by
hinning out.
and Walks.—The roads and walks throughout the station
ave been improved by grading, the construction of culverts,
aveling. They are now in better shape than formerly, and
arrangements for drainage, which have been made, can be
t in fair condition.
s.—The application of considerable quantities of manure is
for the satisfactory growth of orchard trees and in gardening
. Supplies are now being secured from the village barnyards
ost—the hauling being done by the station team.

THE BOTANIC GARDEN.

By Edward Lee Greene.

anical garden has always and everywhere been recognized as
portant adjunct to a thorough and efficient course of instruc-
e knowledge of plant life in general. The Garden of Economic
ng ago established at Berkeley by Professor Hilgard, is to be
an excellent beginning in this direction, and is doing good
Toward the close of the current year a special apportionment
from the College Aid Fund for the purpose has enabled us to
tive steps in the direction of a more general botanical garden;
proposed, first of all, to form a living collection or garden of
trees, shrubs, and herbaceous plants of the State of California;
in at the same time, as rapidly as our limited facilities will
ose of our neighboring States on the Pacific Coast. No region
rld has a more interesting or varied native vegetation than
; and scarcely more than a beginning has been made at the
study of it as a whole. The moderate climate of Berkeley,
om all extremes of heat and cold, humidity and drought, is
which must prove adapted to the growing of the greatest variety
in the open air, and without irrigation. During the few
hich have elapsed since the movement became authorized, we

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have been procuring from collectors in several parts of the State suc seeds as they could obtain, and have received several valuable invoic of living plants and shrubs. Upwards of a hundred select specie chiefly from the southern counties, are already thriving on the sma plot of ground specially allotted; and, although the season for seed ar collecting in the various mountain districts is not yet past, we are possession of seed packets to the number of six hundred species ar more. It is therefore confidently expected that the next growing seas will enable the Station to exhibit an interesting garden of native plan from many and divers localities within the State, arranged systematicall and inviting the studies of the systematist and economist alike.

The prospective new plant house, to be constructed under the supe vision of Professor Hilgard, will furnish a welcome and most importa accessory to the work undertaken, as giving the means of growing t more curious and instructive of tropical plants, along with those economic value.

OLIVE CULTURE AND OLIVE OIL.

OBSERVATIONS ON OLIVE VARIETIES.

By W. G. KLEE.

(*Experiment Station Bulletin No. 85.*)

[The increasing prominence of olive culture in this State gives imp tance to all light that can be thrown upon the subject; the more as the slow growth of the tree renders mistakes made in the selection varieties both costly and difficult of rectification. It is therefore t intention of the Station to subject both the growing trees and the fr and its products to the most thorough comparative observation a investigation as quickly as the material shall be obtainable. In t meantime the observations of Mr. Klee (recorded below) appear sufficient practical importance to justify their publication at this tir

It is evident that, both with respect to the production of oil and th of pickled olives, the proportion of kernel to meat is a matter of mean importance, when we see, as is shown below, that this proporti varies all the way from 8 to over 34 per cent. Some have the impr sion that the oil of the kernel, or pit, forms a considerable proporti of the product, but the investigation of this point, made by Mr. Paparelli, upon the common olive of central Italy, showed this prop tion to be as one to thirty, while in the Mission olive, noted for rarity of sound kernels, the proportion was found, by Mr. Ad. Somm of the University, to be as one to one hundred and sixty-two; hence the oil-maker, as well as to the consumer of pickled fruit, the data gi will be of some interest.—E. W. HILGARD.]

The following records and table show the growth of a number varieties of olives as the result of several years' observations, and i hoped will add to our knowledge of some of the numerous varie now cultivated in this State. This is, of course, only the beginnin observations which will be continued for years to come. Nearly all varieties enumerated are now growing at the four different experim stations, viz.: Berkeley, Paso Robles, Jackson, and Tulare, and we sh thus have a good opportunity to test their respective value in these f

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t sections. Those at Berkeley were planted five years ago, while t the other stations were set out only a year ago (1889), and thus but few data of value.

observations of the varieties growing on the grounds of the Cali- Nursery Company, Niles, and at Fancher Creek Nursery, Fresno, personally had the opportunity to make, through the courtesy of espective managers, Mr. John Rock and G. C. Roeding, who, as Mr. Juan Gallegos, of Mission San José, kindly allowed me to pecimens for identification.

he text following the table only a description of the fruit is given, he foliage varies so much, as between old and young trees, as to t difficult of use as a distinctive mark.

Series I," the varieties are arranged in accordance with the pro- of the pit to the pulp, by bulk, as shown in the last column of all table preceding their discussion. The measurement given nts, of course, the average of a greater or less number, made on fruit. We can thus obtain a fair idea of the actual bulk of pulp ed in a gallon of the fruit. This, it is true, is only one of the that determine the value of the olive. The actual yield of oil, e quality of the latter, remain to be determined hereafter, but le, as it is, will serve for purposes of investigation, and is cer- of practical interest.

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TABULATED STATEMENT OF GROWTH AND BEARING OF VARIOUS OLIVE VARIETIES IN BERKELEY, AND OBSERVATIONS IN OTHER LOCALITIES.

Name and Age When Planted.	Cuttings, or Grafted Trees.	Diameter of Stem.	Diameter of Crown.	Height.	Observations of Habit of Growth and Bearing in Berkeley.	Observations in Other Localities.
Regalis— April, 1885; two years old.	Grafted on Redding Picholine.	One inch.	Very small.	5 feet.	This specimen is in a rather unfavorable spot; growth poor.	Bearing well at Niles, as well as in Fresno.
Polymorpha— April, 1885; two years old.	Grafted on Redding Picholine.	One inch.			Slow grower here; no sign of fruit yet.	Bearing fairly well at Niles; at Fresno, little fruit yet.
Macrocarpa— April, 1885; two years old.	Grafted on Redding Picholine.				Seemingly a good grower; no sign of fruiting yet.	At Niles, bearing fairly well; at Fresno, a tree stunted by close pruning has very large fruit.
Columbella— April, 1885; two years old.	Grafted on Redding Picholine.	Very small; not measured.			Lacks vigor; in this instance most likely due to poor union of graft.	Bearing well both at Niles and Fresno.
Nevadillo blanco— April, 1885; one year old.	Small rooted cuttings.	No. 1, 3 inches. No. 2, 2⅜ inches. No. 3, 2¼ inches. No. 4, 2¼ inches. No. 5, 2 inches. No. 6, 1½ inches. No. 7, 1⅜ inches. No. 8, 2½ inches.	9 feet. 8–9 feet. 8 feet. 7 feet. 7 feet. 7 feet. 7 feet. 7 feet.	10 feet. 9 feet. 9 feet. 9 feet. 8 feet. 8 feet. 8 feet. 9 feet.	A very strong grower; light silvery foliage; drooping habit; has not bloomed yet.	One small tree bearing well at Niles; at Mission San José a number of trees bearing well; also at Fresno. Seemed more tender than some others, and suffered from frost at Experiment Station, Jackson, in January, 1890.
Manzanillo No. 2 (true)— April, 1885; one year old.	Small rooted cuttings.	No. 1, 1½ inches. No. 2, 2½ inches.	5 feet.	6 feet. 6 feet.	Upright, moderate grower, sparse foliage, shows tendency to be straggling. Several trees showed blossoms last spring; none set yet.	Four-year old tree bearing a few fruits at Niles; at Fresno, trees from the imported truncheons are bearing well; fruit large. Seems very hardy as regards frost.
April, 1886.	Six cuttings made from pieces of truncheons average:	One inch.	4 feet.	6 feet.		
Pendulina— April, 1885; two years old.	Grafted on Redding Picholine.	No. 1, 1½ inches. No. 2, 2 inches.	6 feet. 7 feet.	8 feet. 8 feet.	Strong grower, with decidedly drooping habit; bloomed considerably, but set only a few fruits.	Shows tendency to coulure, but bears well nevertheless at Niles; at Fresno, the setting was poor, owing to coulure.

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Rubra— April, 1885; two years old.	Grafted on Redding Picholine.	One and one half inches.	5 feet.	6 feet.	Showed blossoms last year, but did not set; this specimen is affected by neighboring trees.	A fair upright grower; bears early and abundantly. Observed at San José, Niles, Fresno, and Riverside, San Bernardino County.
Præcox— Two years old; 1885.	Grafted on Redding Picholine.	One and one half inches.	5 feet.	6 feet.	Fair grower; showed blossoms this year, but did not set.	Bearing well both at Fresno and Niles.
Atro-rubens— April, 1885; two years old.	Grafted on Redding.	Very poor specimen, probably due to imperfect union of the graft.				At Niles coulure seemed to be the cause of poor setting.
Uvaria— April, 1885; two years old.	Grafted on Redding Picholine.	Original specimen died; was replaced last year.				Bears very abundantly, both at Niles and at Fresno.
Atro-violacea— April, 1885.	Grafted on Redding Picholine.	One and one half inches.	6 feet.	7 feet.	Fair grower; no sign of fruiting this year.	Bearing well at Niles; at Fresno, fair yield.
"*Redding Picholine*"— April, 1885; one year old.	Small rooted cuttings.	No. 1, 2½ inches. No. 2, 2½ inches. No. 3, 1½ inches. No. 4, 2½ inches. No. 5, 1½ inches. No. 6, 2½ inches.	8 feet. 7 feet. 6 feet. 6 feet. 5 feet. 6 feet.	9 feet. 8 feet. 7 feet. 7 feet. 6½ feet. 7 feet.	Fair upright grower; some trees blossomed considerably, but nearly all dropped off.	Bearing well at Niles, and at Fresno as well as in any part of the State.
Razzo— April, 1888.	Small rooted cutting.			4–5 feet.	A thrifty grower.	
Correggiolo— April, 1888; three years old.	Small rooted cutting.			5 feet.	A thrifty grower.	

NOTE.—Observations at Fresno refer to Fancher Creek Nursery, Fresno. Observations for Niles refer to California Nursery Company's grounds, Niles.

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Olive Varieties Ranked According to Per Cent of Pit.

Variety of Olive.	Dimensions of Fruit, in 16ths of an Inch.				Pit, per cent of Bulk.
	Whole Fruit.		Pit.		
	Length.	Width.	Length.	Width.	
Regalis	17	13	9	5	
Manzanillo No. 1	16	13	9	5	
Nevadillo blanco	16	10	10	4	1
Pendulina	12	9	7	4	1
Columbella	14	11	8	5	1
Mission	16	10	10	5	1
Polymorpha	19	12	12	6	1
Rubra	12	8	8	4	1
Rock's Oblonga	15	8	11	4	1
Mignolo*	9	7	8	4	2
Redding Picholine	8	6	6	4	3
Uvaria	13	9	10	6	3

Series I.

Regalis.—Imported by John Rock from France. Almost perfect rounded-oval; when ripe, dark purple or black; large, one and o sixteenth inches long by thirteen sixteenths of an inch in thickne flesh firm; pit nine sixteenths of an inch by five sixteenths of an inc generally straight, square at the base, pointed at the apex. Ripe slightly ahead of the broad-leaved Mission variety.

Manzanillo No. 1.—Imported by F. Pohndorf from Spain, and grow by Juan Gallegos, Esq., at Mission San José; large, one inch long thirteen sixteenths of an inch in thickness; regular rounded-oval; straight, strongly pointed at the apex, nine sixteenths of an inch lon five sixteenths of an inch thick. Ripens early—several weeks earli than the broad-leaved Mission. In many respects this resembles t *Sevillano Gordal*, or queen olive of Spain, more than any variety I ha examined in this State. The fruit grows on long stems, and in a win place would be liable to fall. The pulp parts readily with its bitterne and is exceedingly rich when pickled.

Polymorpha.—Imported by John Rock from France; very large, ova oblique and pointed; one and three sixteenths inches long by twel sixteenths of an inch thick; pit twelve sixteenths of an inch by six si teenths of an inch in thickness, square at the base, strongly pointed the apex; flesh firm. Time of ripening falls much like the broad-leav Mission; fruit grows on strong stems in clusters of two or three.

Macrocarpa.—Very much like above; we have not had specime enough to make out a distinction.

Columbella.—Imported by John Rock from France. General for broadly oval, fourteen sixteenths of an inch long and eleven sixteent of an inch thick; very even in size; remarkable for the peculiar pa yellow color which all the fruit assumes before turning fully ripe a becoming dark purple; pit small, eight sixteenths of an inch long five sixteenths of an inch in thickness; straight and sharp point The pulp seems to part with the bitterness slowly, but when extracte the flavor is very rich. Ripens late—later than the broad-leav Mission.

* Measurements taken from Caruso's cut of this variety, for the sake of comparison.

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llo Blanco.—Imported by F. Pohndorf from Spain. Oval, oblique, pointed, one inch long by ten sixteenths of an inch sembling somewhat a broad-leaved Mission, but is generally ngated in proportion to its diameter than the latter. Pit small, nd generally pointed at both ends, ten sixteenths of an inch our sixteenths of an inch thick. The fruit is borne in clus- ree to five. Its time of ripening does not appear to be much an the broad-leaved Mission.

ariety has been propagated considerably at the nursery of the ent Station, and has been scattered widely by distribution e during the last two or three years. The reports received se trees go to show that it is a remarkably robust and fast n the hottest as well as in the coolest portion of the State. his olive prove a good and constant bearer, as there is every believe, it will prove a valuable addition to varieties of olives. of ripening may be an objection to its planting in localities coast, subject to early frosts. Reports indicate that it is more frost than certain other varieties, a fact which is undoubtedly almost constant growth, and shows that moist soil should be or this variety, perhaps, more than for any other.

nillo No. 2.—Imported by F. Pohndorf from Spain. As the small apple") indicates, this variety is of an unusual shape, the Dalmatian (Hervaza), resembling it. It is nearly round, it of rounded-oval shape, rather squarely cut off at the base. pecimens were few and not quite fully grown, measurements given. This variety ripens early—several weeks earlier than l-leaved Mission olive; the fruit grows generally singly on long

ariety, which I have seen fruiting in Fancher Creek Nursery, sno, has the same straggling and sparse growth which char- the variety I have designated as Manzanillo No. 1. It is sup- be this variety (No. 2) which has been disseminated from the although as Mr. Gallegos has received the other variety (No. 1) same source as we, under the name of Manzanillo, the two e been mixed, the wood and foliage being much alike.

ina.—Imported by John Rock from France. This variety is of oval shape, rounded at both ends, quite variable in size, many naining small and undeveloped; twelve sixteenths of an inch nine sixteenths of an inch thick; pit seven sixteenths of an and four sixteenths of an inch thick, exclusive of the small, ints often found at both ends. The fruit grows in clusters of to five; the pulp parts very readily with its bitterness. This nust not be confounded with the Pendoulier, a variety imported lbert Montpellier, and fruited at his place at Vacaville. The riety is somewhat larger and more of an ovate shape.

a.—Imported by John Rock from France. An olive of a pecul- like shape, being narrow at the stem end, broad at the point, and strongly oblique; fifteen sixteenths of an inch long and teenths of an inch in thickness; pit curved, eleven sixteenths ch long by four sixteenths of an inch in thickness; generally at both ends. The pulp loses its bitterness comparatively n pickling. This olive ripens quite early—at least two or three rlier than the broad-leaved Mission; color dark purple.

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Coutance, as well as several other authors on the olive, gives th name of Picholine as synonymous of *Oblonga*. As a matter of fact, th olive imported by Mr. Rock under the name of *Oblonga* is a totall different-looking olive from the variety described and pictured in th Annals of the School of Montpellier (and translated in Mr. Lelong pamphlet on olive varieties) as the Picholine. Rock's *Oblonga* seem to me to belong in the neighborhood of the *Lucques*.

Common or *Broad-Leaved Mission Olive.*—The variety of olive mo generally known as the Mission; thirteen sixteenths of an inch lo by ten sixteenths of an inch thick; ovate, oblique—sometimes ve much so. The pit straight or slightly curved, ten sixteenths of a inch long and five sixteenths of an inch thick; fruit very variable size, growing singly or in clusters of two or three, or even five. Tim of ripening, late, in the coast region, sometimes not before Februar but generally in December; in warmer localities, in November.

Rubra or *Caillon.*—Imported by John Rock from France. Ova slightly oblique, looks a good deal like a small Mission olive; twel sixteenths of an inch long and eight sixteenths of an inch thick; straight, pointed, eight sixteenths of an inch long and four sixteent of an inch thick. This variety is an early one, and ripened three four weeks earlier than the common Mission variety; is of a jet bla when ripe. This variety, it appears, has been imported by sever different persons; among others Mr. Bliss, of Riverside, on whose pla I saw trees of it three years ago, heavily laden with fruit.

Uvaria.—Imported by John Rock from France. Oval, regular, a rounded on both ends; thirteen sixteenths of an inch long and ni sixteenths of an inch in thickness; pit straight, heavy, ten sixteent of an inch in length and six sixteenths of an inch in thickness. La later than the common Mission olive. Color dark purple or bla when ripe. The name "grape-like," is well chosen, the fruit growi in clusters, as many as seven together, and in shape themselves sembling the grape.

"*Redding Picholine.*"—Imported by the late B. B. Redding. A perfe oval in shape, eight sixteenths of an inch long and six sixteenths an inch thick. Ripens early, several weeks earlier than the comm Mission; dark purple or black when ripe. In pickling, the pulp los the bitterness quickly, the fruit being very pleasant. This variety h been propagated extensively in the State, and until fruiting, was su posed to be a large "pickling" variety; then, not having an adequa description of the Picholine at hand, it was believed for a number years to be rightly named after all; various authors designated t Picholine as a small olive. Two years ago, in the Annals of the Sch of Montpellier, France, there appeared a description of the Picholine known there. Mr. B. M. Lelong had this promptly translated for h report, and deserves credit for having thus settled that the variety Redding's introduction is not the French Picholine. The Redding Pich line, which name has naturally suggested itself for want of a better, h produced oil of good quality. In proportion of pulp to pit it is b slightly inferior to the Italian *Mignolo* or *Gremignolo*, judging fr Caruso's description. The only record in regard to the yield of oil have had occasion to examine into was made several years ago by M L. A. Gould, then of Auburn, who, from two thousand five hundr pounds of olives, chiefly Picholine, only obtained twenty-four gallons

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ing a percentage of 7.04. The Italian *Mignolo*, in Caruso's work, s only nine sixteenths of an inch, with a thickness of seven hs of an inch; the pit being large, eight sixteenths of an inch four sixteenths of an inch thick, which places it very near the Picholine. The strong recommendation of this olive by the authorities, for foggy regions, makes this variety, nevertheless, ng and worthy of trial in such places.

Series II.

se no measurements have been made, but some record of growth eral behavior is given in the preceding table.

ubens.—Imported by John Rock. According to Coutance, synon- with *Salierne* or *Sayerne*; of a violet-black color, covered with bloom; rounded at the base, pointed at the top; cultivated out Languedoc; valuable for oil.

tro-violacea.—Imported by John Rock from France. A good- ve, making oil of first quality, according to soil.

or *Frantojano.*—Imported by Judge J. R. Logan, of Santa Cruz. from the Lucca district, in Italy; oval, medium size or below; , in its native country, a very fine oil.

giolo, or *Grossajo*, or *Frantojo.*—Imported by Judge J. R. Logan, Cruz. An olive from the Lucca and Pisa districts, in Italy, ng some of the finest oil; fruit medium-sized; of inverted-oval) shape, narrower at the stem end, broader toward the point.

ou, or *Olea amygdalina.*—Imported by Mr. C. A. Wetmore. A luable variety, both for oil and pickles.

e, or *Olea adorata.*—Also imported by Mr. Wetmore. A peculiar, shaped olive; one of the richest for pickles.

n Varieties.—A number of years ago my attention was called ct that there existed several distinct forms or varieties of "Mis- ves. We are propagating now three apparently quite distinct *a*) Broad-leaved or common Mission (already described); (*b*) leaved Mission; a variety received originally from L. A. Gould, rn, described as having a somewhat larger fruit than the com- ssion, and a more straggling habit; (*c*) *Early Mission*, procured A. Wheeler. It is of the Mission type, but ripens at the end er in Alameda County. At Pomona my attention was called l, large tree, growing on the ground of Rev. Mr. Loop, which, l, bore a large olive, ripening in October. Whether the two are l or not I do not know.

a.—Obtained from Mr. George Ladd, of Atwater; imported by N. Milco from Dalmatia. This variety fruited at Atwater and resembles somewhat the variety called Pendoulier, speci- which are fruiting at the ranch of A. Montpellier, near Vaca- Further examination is necessary to determine whether the two tical.

za.—Obtained from the same source as the above. This variety sembles the Manzanillo in shape, but the pit of the fruit is more cut off than that of the latter. The trees of the two varieties lly distinct. The *Manzanillo* has an upright, sparse growth, k-colored wood. The *Hervaza* is of drooping habit and the

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wood is light-colored. Time of ripening of the two falls about the sam at Atwater, viz., in the beginning of October.

UNIVERSITY SEEDLING OLIVES.

The seedling olives in the Berkeley experiment grounds have attracte the attention of horticulturists, not so much from any especial promi that they have yet shown as from the ease of their growth, which ough to persuade many others to try to raise a few seedlings. As reported i Bulletin No. 92, chemical tests were made in 1890–91 of the oil from tw of the Berkeley seedlings, No. 2 and No. 10; No. 6 is also an olive th is worth further study, and perhaps two or three more of the seedlin have some value.

The history of the growth of these olives was written in 1890 by th late Waldemar G. Klee, former Inspector of Stations, and found amon his papers. He says:

"In previous reports reference has been made to experiments wit seedling olives at the Station, but as the subject is of considerable inte est and importance, I will give the history of the seedlings. Seeds different named varieties of olives, including *Præcox*, *Atro-violacea*, *Uv ria*, *Atro-rubens*, *Nigerrima*, and others, were received from John Doyle in April, 1880. The seed was imported from France. This l of olives was planted in a well-prepared seed-bed. Before planting, th seeds had been soaked in an alkaline solution, one fourth of a pound a gallon of water. Most of them sprouted the first year, although thr failed to appear until the next year.

"The trees were left two years in the seed-bed, during which tim they made little growth. In the spring of 1883 twenty trees, two each kind, were transplanted to a permanent place in the grounds, in row bordering on a road. The soil there is of a stiff character, and one to two feet depth becomes very clayey. During the first year the trees received some water, but since then very little attention has bee given them outside of breaking the surface of the soil around the tre for a distance of three feet. Their growth was slow; small cuttin were therefore taken, rooted under glass, and set out in the spring 1885. These, in nearly every instance, have outgrown the stocks.

"In 1888 one of the trees showed some blossoms, but did not set. I the spring of 1889 several more trees produced an abundance of blossom but, with an exception of one tree raised from *Nigerrima*, they did n set. This, however, had quite a large number of olives, which were considerable size, and indicated a comparatively early ripening. A fe seedling trees were sent to the Santa Cruz Mountains, seven miles fro Santa Cruz, and planted on very shallow land. One produced a fe blossoms in 1888, and matured a few olives, which were, however, of rath minute size. In 1889 the tree bloomed very freely, but failed to set. Th variety from which was raised both the tree at Santa Cruz and th variety to bloom first at Berkeley is *Præcox*. In habit it is a compa grower, and seems rather dwarfish in character.

"The appearance is against most of these seedlings, and does not fav the hope that they may be something really good. Most of them resemb the wild olive in manner of growth and leaf. Nevertheless, some them are evidently going to produce a better fruit, and perhaps a hard variety may be amongst them. The experiment is of interest as provin

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g it takes an olive to produce fruit from seed in this State, and
n that in this, as in many other instances, precocity is the rule.
the trees fruited at eight years from the seed. A number of
ore at nine years from the seed. In a warmer part of the State
earlier fruitage would have been obtained."

ENING, PICKING, ASSORTING, AND CONSERVATION OF OLIVES.*

By Louis Paparelli.

Ripening.

pening and picking of the olives affect very materially the olive
try, and therefore in gathering them their degree of maturity
e closely noted, for on that depends in a great measure the
and quality of oil that will be obtained.
pening of olives varies greatly according to the nature of the
of the climate, of the exposure of the plantation and of the
, according to the variety cultivated and the kind of manure

m climates and under the influence of strong sunlight the olives
re quickly, and, in general, give a heavy tinted oil, rich in special
matters. In cold climates, on the contrary, the ripening is
and the oils produced are lighter, clearer, and whiter. In moist
climates the olive ripens very late, and the quantity of oil they
ss.
r, clayey soils the maturity is retarded and the yield of oil is
n a fertile, calcareous soil, slightly moist, warm, and rich in
es, the ripening is generally normal and the yield much more
t. The olive grower, in seeking to enrich his soil, should choose
nures which will hasten the maturity of his crop and, at the
e, increase its quantity and improve its quality.
, the maturity will be early or late, according to the variety
d, and according to the northern or southern exposure of the
ts branches; also, according to the form given to the tree in
and to the amount of cultivation given to the soil.
e oil making, the maturity of the olive should be considered
industrial standpoint, not from a physiological one; that is,
ering of the olives should be governed by the quantity and
f the oil that it is desired to produce.
pening of the olive is marked by four variations in the color of
(1) From olive-green to lemon-yellow; (2) from lemon-yellow
purplish-red; (3) from purplish-red to wine-red; (4) from wine-
velvety black. Generally, under favorable conditions of soil
ate, the velvety-black color will mark the proper time for
the olives for industrial uses, though the ripening is physio-
continued for some time longer.
er, the exterior coloration of the olive is not an infallible sign
eness, for there are modifications in this coloration and varia-
ts intensity dependent upon the different varieties cultivated.
also be borne in mind that the velvety-black tint in olives
a cold climate does not represent the same degree of ripeness

ead before the Fruit Growers Convention at Santa Cruz, November 21, 1890.

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that the same tint does in olives grown in a warmer one; so that thes and other general considerations, though giving an approximate idea when to gather the crop, must be supplemented by local experienc which alone can determine the exact time.

While noting the color of the outside of the olive, it must also be cu and the pulp examined, to see whether it is whitish or colored; obser ing, also, the quantity of the water and the droplets of oil it contain Note should also be taken of the stone, whether it is still white, or h become brown; and of the taste of the juice, whether sweet or bitte and so on.

If, in the extraction of the oil, high quality is the object in view, t olives must be gathered when they show the black-velvety color in co climates; but, as in warm climates this color corresponds to a certa degree of overripeness, the fruit must be gathered while still yellowis and hardly commencing to redden, in order to obtain an oil of equ delicacy.

If, on the contrary, the oil-maker cares little about the high quality his oil, but aims principally at quantity, he can gather his olives their complete maturity. He ought, however, never to leave them the trees longer than this, for they will gain nothing in oil, and will r the risk of being spoiled by climatic causes, or by birds and insec and in this case the oil obtained will be of even inferior quality to th intended, and it will keep poorly.

Summarily, then, it may be said that olives gathered a little *bef* their perfect maturity yield an oil of superior delicacy and fruity tas those gathered a month later give an oil of ordinary quality; wh those gathered very late give a very inferior oil, which can only be us in the manufacture of soap, or for illuminating or lubricating pu poses, etc.

The oils furnished by fruit of different degrees of maturity may characterized thus: Very unripe olives furnish a bitter oil; those whi are nearly ripe give an oil which has a fruity taste, and, everythi considered, is better than any of the others; olives which are complete ripe produce an oil with a strong flavor, which is hardly agreeable, a is subject to become rancid; overripe olives yield a very greasy, thi oil, which is very difficult to keep from spoiling.

Methods of Gathering the Olives.

The ripening of the olives not being uniform on all trees, and varyi even on the same tree, two or three separate pickings are general made. The picking should be done in good weather, when the atm phere is clear and dry, and when the soil is not damp from previo rains.

Four ways of gathering the olives are practiced: (1) Picking up th which have fallen on the ground; (2) picking by hand; (3) beating t trees; (4) shaking the branches. The falling of the olives may caused by climatic influences, or by animals, or finally by overripene These fallen olives are gathered and kept separate, to be used in t making of oil of inferior quality.

Hand-picking is the method most to be recommended, as it does n injure the fruit in any way; and in a country like California, where t olive trees have not yet arrived at any great height, it should be pr

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clusively. Hand-baskets are the best receptacle to use in this gathering.

ng the trees with a pole or stick is the worst possible way of ng, and should only be practiced in exceptional cases, as it dam- h the fruit and the tree, doing harm also to future crops.

ng the branches to make the olives fall, though less pernicious ating the tree, is not to be recommended except in certain cases; when, from the height of the tree or the extent of the branches, es grow out of reach of the workman's hand. As shaking the detaches the spoilt or overripe fruit, it cannot be considered as al mode of harvesting.

onclusion is that it is absolutely necessary to pick by hand if we avoid all danger of injuring the quality of the oil, or of lessening re production of the tree. Beating and shaking should be limited exceptional cases where the olives cannot be reached, by any e means, by the hand of the workman. It must not be for- o spread cloth sheets under the trees to save the olives from ill more damaged by falling directly on the bare soil.

Sorting.

lives should be sorted to a certain extent during the gathering, re completely and carefully afterwards at the oil mill. This is of great importance, as the fruit communicates to the oil all qualities and all the defects that it possesses when worked.

nsport the olives from the orchard to the oil mill, sacks should e used, but some receptacle with unyielding sides, in order to the fruit from being bruised on the way. For this purpose of different sizes and shapes are most suitable, but in case they be procured, whatever is used must dry easily, and not be too r absorbent, like soft wood. The handling of the olives in fill- emptying the baskets should be done very carefully, in order reak the skin; for in that case, the pulp being exposed to atmos- gencies, fermentation is likely to set in and extend to the rest, g it impossible to preserve them for the time desired. Oil made h fruit will not only be inferior from the beginning, but will ckly acquire a very disagreeable, rancid taste.

bject in selecting is to separate the fruit into four different quali-) The good olives; (2) the dry or frost-bitten ones; (3) those ave been broken, crushed, or in any way damaged in gathering; spoiled olives. It is hardly necessary to say that in sorting over, es, twigs, etc., must be picked out.

y be objected that to put all these details in practice would o great an expenditure of time and money; but when we con- e much greater price for which superfine oils can be sold, and there will be in making only one grade of oil from the olives of t qualities, the practice of sorting will be found to be an economy. eadily be done by women and children. Sorting by hand alone y be practiced on a small scale, but by the use of an appropriate us, moved by some motive power, large quantities can very be sorted. This apparatus does not make a very complete n, but is a great saving, even if the separation has to be finished d. A good grader would do much of the work.

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Conservation.

In a rational treatment of olives they ought to be kept as short a tim as possible after picking; for to keep them for any length of time, i order to work them at one's convenience, is as little practicable as woul be the keeping of a similar quantity of grapes to be crushed later. Th principal end to be kept in view in the keeping of olives, is the pre vention of all heating of the mass, that would cause fermentation; bu as the time which elapses between the picking and the working shoul be as short as possible, the capacity of the oil mill should be propor tionate to the size of the olive plantation. In this way the delays an losses which are so common in many oil factories will be avoided. C course it is useless to attempt to preserve any but the olives picked b hand and in the very best condition; all others must be crushed imme diately, as they cannot be preserved by any practical means.

The only good method of preservation is to make use of trays o shelves of willow or cane; all other methods offer insuperable objec tions. The trays are arranged on shelves in a cool and well ventilate room facing north. The thickness of the layer of olives on each tra ought to average about two inches and a half, and under no circum stances should it exceed four inches. Frequent observations of th temperature should be made on each layer, and if the temperature rise above 59 degrees Fahrenheit they had better be taken to the mill a once. In order to prevent any elevation of temperature, it is necessar to turn over the olives often and so cool them by aëration.

With regard to the quality of the oil, the keeping of the olives shoul be as brief as possible. It is always best to work them immediately but as that is not generally possible, three or four days should be th limit. In this time the fruit loses a portion of its water of vegetatio which in a rainy season is doubtless of some advantage.

Even when all the conditions for the preservation of the olives ar favorable they must not be kept too long, as the oil may lose, but wil never gain, in quality. In conclusion, I may say that the oils of Nic and Lucca owe their reputation to the fact that there the olives ar worked immediately after gathering, or are only kept for a short tim and with all the care demanded by a rational method of treatment.

PROPER FERTILIZATION FOR OLIVE TREES.*

By L. Paparelli.

Were we to believe, absolutely, certain authors, who have written tha olives grow and bear on the most barren ground, and consequently tha all manuring should be dispensed with, our olive culture and oil-makin would be in great danger. But in general, intelligent growers posses ing experience with other crops, will know that a completely barren so would never suffice for the life of any plant, even the least exacting. I is not true, then, that the olive thrives in all soils, and that it prefe those of inferior quality. On the contrary, we may be sure that it i not at all advantageous for the farmer to reserve the most sterile land for his olives; the trees will look badly, and the quantity of fruit reape will always be extremely small; the oil extracted therefrom could no

* Published in the "California Fruit Grower," March 14, 1891.

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ry inferior in quality to that obtained from olives well cared
olive likes a permeable and moderately damp soil; permeable,
may spread and grow deep roots; rather damp, so that it may
dity and dryness. Finally, I must say that as the olive, like
nts, takes from the soil the ingredients necessary to its vege-
is important to replace those ingredients in the ground by
.

Chemical Composition of the Olive Tree.

speaking of the fertilizers that best suit the olive, let us glance
emical composition of its ashes, according to the analyses I
le, in order to know better what are the principal substances
to obtain a good growth and production. The *percentage of*
ined for each one of the parts analyzed was as follows:

Analysis of the Olive Tree.

	Wood.		Leaves.	Fruit.
	Large Branches.	Small Branches.		
of ash	0.941	0.963	2.506	1.422
organic matter	99.059	99.037	97.494	98.578
	100.000	100.000	100.000	100.000
mposition of the Ash.				
	19.165	20.492	30.260	60.744
	2.250	4.778	1.614	2.225
	57.574	50.412	46.155	16.282
	3.652	6.760	4.424	3.770
n	3.275	3.284	1.414	0.096
acid	11.684	12.437	10.470	8.334
acid	2.119	1.160	4.754	1.104
	0.281	0.677	0.649	5.670
	Trace.	Trace.	0.260	1.581

ther determinations of the proportion of nitrogen contained in
ent parts of the olive, gave the following figures:

rge branches	0.881 per cent.	As nitrogen.
all branches	0.897 per cent.	
	0.912 per cent.	
lp	1.120 per cent.	As nitrogenous matter.
docarp	1.062 per cent.	
rnel	13.891 per cent.	

substances, then, should be found in the soil and manure, in
t the olive tree shall remain vigorous and productive?
the above analyses we can clearly see that there is an abun-
potash in the wood, in the leaves, and especially in the fruit;
ind a good quantity of lime and phosphoric acid. In general,
tity of oil is in proportion to the potash; the more the olives
f potash, the more they are rich in oil, which is, moreover, of
quality.
perience of many years has proved to the European olive grow-
trees growing in calcareous lands are the richest in mineral
and give oil of the best quality; these olives are always richest
h. The other ingredients are not considered so important,
the small quantity needed is always found in the soil. It

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seems, also, that an excess of lime existing in the soil facilitates the assimilation of the potash by the plants; therefore, we may say that the olive needs a calcareous soil, rich especially in potash and also not deficient in phosphoric acid. Besides the ingredients mentioned, it is important to observe the large quantity of nitrogenous matters contained in the fruit, the kernels being richest in this respect. This fact is not only important in regard to the crop, but also to reproduction by seed. Without a sufficient supply of nitrogen the kernels would not be completely developed, and therefore the few plants that we should obtain from them would not be vigorous, and would not make fine trees, even after being grafted with good varieties.

From all that has been stated above, we see that potash, phosphoric acid, and nitrogen are the substances which should be brought back to the soil by fertilizers. The question should now be considered with regard to the special conditions of California soils, in order to determine the fertilizers which suit best the nature and the needs of the olive trees in this State.

Fertilizers.

From the investigations of Professor Hilgard,* we know that nearly all the soils of California may be considered as abundantly supplied with lime; almost the same can be said for the potash, while phosphoric acid is more sparingly represented. Nitrogen is also found in small quantities only, except in some localities where there is a certain amount of nitrate. According to calculations made from my analyses, it appears that a large, robust olive tree, well cared for, in a soil suited to its development, takes away yearly, in its growing and crop, the following proportions of the principal ingredients:

	Grams.	Pounds.
Potash	460	1.016
Nitrogen	909	2.006
Phosphoric acid	171	.458

Summarily, it may be said that California soils are naturally very well adapted to olive culture, provided we increase, by the use of manure, their proportion of nitrogen and phosphoric acid in localities where these ingredients are deficient. It is not necessary to use special potassic fertilizers, both because the general condition of those soils does not require them, and because, since special fertilizers are usually of very quick action, they would not suit the nature of the olive tree, which, growing slowly, needs fertilizers that act slowly and for a long time. Being so fortunate as to have good soils in this State, we should provide for maintaining their fertility; and in order to obtain constant success in olive culture, I would recommend the use of a compound fertilizer, more convenient to the olive growers than high-priced special fertilizers. A very good fertilizer may be prepared by making a compost of stable manure, leaves, and olive twigs, black waters obtained in pressing oil, vegetable ashes, especially those from the olive, a little sheep corral manure, or human feces, scraps of horn, bones, and offal from the slaughter-house, and wool and leather waste. We should also

* See Bulletin No. 88 on "The Use of Fertilizers in California," in another place.

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neglect the residue from the olives themselves, on account of valu-
ıbstances they contain, both in the natural state or as ashes. Oil
or example, contains 9.71 per cent of nitrogenous matters, and its
3.94 per cent of potash and 9.45 per cent of phosphoric acid. All
ostances mentioned, or as many of them as are at hand, must be
ixed together and well cured in the manure pit, adding also
and leaf mold found in the neighborhood of the farm. The
for curing the animal manure with so many other matters is to
sh its concentration, and so have a vegeto-animal fertilizer,
in my opinion, best suits the olive tree placed in favorable con-
of climate and soil. Mineral or animal fertilizers, used alone,
good for olives, while a vegeto-animal fertilizer serves not only
ore the olive tree, but also to maintain a certain moisture and
s in the soil, which is very important in warm countries. It
ssary to neutralize the strong acidity of the black waters pressed
naking, by means of lime in the proportion of one and one third
per gallon of water.

Time and Mode of Manuring Olive Trees.

ıld say, first of all, that the olive tree planted in a soil which suits
not need much manuring, and that in order to obtain oil of a
r quality the manuring must never be abundant; because while
ınt manuring gives a large crop, the quality of the oil resulting
ior and difficult to keep. Growers must, however, have both
y and quality in view. Manure must always be put in at a cer-
stance from the roots, otherwise these would be damaged instead
efited. For level lands dig a shallow trench around the trunk at
nce varying according to the age and size of the trees. That
should be nearly sixteen inches in depth, and distant from two
six and one half feet from the trunk. In order to aërate the
f soil where the roots are, the trench should remain open for
orty days in case of compact soils, but only for fifteen days in
light ones. After that time the bottom of the trench is covered
thin layer of fine earth, and upon it is placed the well-cured
e. The trench is then filled with half of the earth excavated, and
t is used when the soil around the trunk settles. For hill lands
nure is placed in a round hole made in the soil on the upper side
tree, so that the water in filtering through the soil carries the
ve juices into contact with the roots below. The quantity of the
e to be given varies with the age and condition of the tree, the
of the soil and of the manure, and finally according to the
ls of culture.

ompost, prepared more or less as indicated above, we may give
rty to sixty pounds to each tree, supposing the conditions of soil
ımate be favorable. But the grower should vary the quantity
ng to the special conditions of his location, and also according to
perience, if he has grown olives for several years. We must,
er, maintain the equilibrium of vegetation by pruning proportion-
o the quality of the soil or the quantity of the manure employed.
manuring was abundant, little pruning ought to be given; if, on
ıtrary, the manuring was slight, pruning ought to be heavier.
way the vegetative equilibrium is maintained and the produc-
ll not suffer. It is impossible to indicate precisely the time for

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manuring. Autumn is the time for cold soils where manure will decompose very slowly, so that at the starting of vegetation the trees may find the nutritive ingredients ready for use. Spring is the proper time for warm, very permeable soils, or those subject to be washed by rain. If such soils were manured in autumn, very little nutriment would remain at the commencement of growth in spring. Annual manuring is, of course, the most rational, and should be calculated so as to replace, as nearly as possible, the ingredients withdrawn by the preceding crop.

Pickling Olives.

For the purpose of pickling, the olives must be picked while green, namely, one month or six weeks before maturity; the latter, of course, is variable, according to climate and variety cultivated. The olives should be picked by hand, early in the morning or late in the evening. It is necessary to select the best fruit only, rejecting especially that which is spoiled or imperfect, and also to free it from leaves and stems.

All the modes of preparation can be reduced to two—one using a lye of greater or less strength, the other pure water only. The lye treatment is as follows: The olives are placed in vats, where they are immersed in a solution of caustic soda (concentrated lye) of the strength of 6 degrees Baumé, equivalent to about four ounces per gallon. After some hours, when by several tests the fruit is shown to have been well cured by the lye, this solution is drawn off and replaced by soft water which must be changed several times during three or four days, until it is completely clear. Then the olives are placed in kegs, with a brine consisting of one ounce of salt and thirteen ounces of water for each pound of olives, or a gallon of brine containing ten ounces of salt to ten pounds of olives.

The lye may also be made with one part of quicklime and six parts of fresh wood ashes, well sifted. After having been in this lye six hours the olives are taken out and placed in fresh water, where they will remain during eight days, being careful to renew the water every twenty-four hours. After this time the olives are placed in a brine of salt and water, as stated above. In this manner they are preserved very well. They will be in a condition to be used in from one to two months, according to taste.

To preserve olives without lye they are placed in a crock, or wooden vat, in which they are submerged in pure water, covered with lemon leaves, and a grated frame placed above them to keep them submerged. The olives will remain one month in this liquid, which must be changed every twenty-four hours. After this the fruit is placed in vats; in the bottom a layer of salt, then a layer of olives, then salt again, and so on, the proportion being twelve pounds of salt to one hundred pounds of olives. This being done, the olives remain in the vats forty-eight hours, and after that clean water is added and a layer of one inch of salt placed on top. One month after this treatment they can be used. The olives can also be improved by placing aromatic herbs, like fennel, pistachio, etc., among them after the first treatment.

The strength of the lye above mentioned is intended for average sizes of olives; for smaller or larger fruit, the proportion of lye must be diminished or increased, also in case of those varieties which lose the bitterness sooner or later. Experience alone must be the guide in this matter.

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OTES ON CALIFORNIA OLIVES; THEIR ADAPTATIONS AND OILS.

By L. PAPARELLI.

(*Experiment Station Bulletin No. 92.*)

iew of the constantly increasing importance olive culture is g in California, I commenced last October, under instructions ofessor Hilgard, a study of the different olive varieties cultivated State, and of the quantity and quality of the oil produced by

ime that could be given to this subject being limited by other what I considered most important was the identification of the s, from which afterward were obtained small samples of fruit, d for a chemical test as to the quantity of oil each contained, far as feasible, its quality.

bservations were thus necessarily confined to the plantations at y, Niles, and Mission San José, more especially to that of the oint, where maturity being earlier than in the other two locali- were enabled to obtain samples sooner.

rst visit was made at the beginning of November, 1890, to the ion of the California Nursery Company, at Niles, where Mr. John ne President of the company, kindly showed me all the varieties ed, and gave me much information regarding the large collec- foreign varieties, well cared for but with only a light crop; partly, ss, on account of their imperfect acclimation. The maturity was e; the variety Rubra alone was just beginning to change color. ckwardness was probably due principally to their growing on und, for other trees but a short distance away on high ground a more advanced degree of ripeness. This exemplifies the rule pecially in cool climates, the plantation on high ground is better o olives, because they receive there more air, heat, and light, so eeded by these trees.

narked, also, some damage to the crop caused by a very strong hich had blown for several days. This damage was still greater ion San José and at Berkeley, where I think that not only the ut the dryness of the soil, had contributed much to the falling large proportion of the fruit. In fact, the rain coming soon enefited somewhat the fruit which remained shrunken on the proving it in appearance and size.

ttention was then directed to the olive trees of Professor Hilgard, ion San José, and there I began the identification of the varieties, ch I could determine only twelve—others being too young or fruit. According to my observations, these varieties may be d as follows:

rding to the Time of Ripening.

Nevadillo blanco.
Atro-violacea.
Pendoulier.
Pendulina.
Redding Picholine.
Manzanillo.
Mission.
Polymorpha.
Oblonga.
Regalis.
Columbella.
Uvaria.

According to Productiveness.

1. Mission.
2. Nevadillo blanco.
   Columbella.
3. Uvaria.
   Atro-violacea.
   Redding Picholine.
   Oblonga.
   Regalis.
4. Pendoulier.
   Pendulina.
   Manzanillo.
   Polymorpha.

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It must be remembered that, with the exception of the Mission olive, most of the trees are young, and therefore the amount of the crop may not correspond with what would be obtained with older trees, so these data must be taken with due allowance.

In the plantation of the University at Berkeley the succession of ripening was the same as at Mission San José, but the fruit matured, correspondingly, from one to four weeks later. The yield ranged from small to very small on all the trees, with the exception of the Nevadillo blanco and the Mission, which had a good crop. Some trees of the former are already about seven years old, and those of the latter are represented by two large and old specimens. All the other trees are from four to five years old.

The results obtained should, however, be taken only as a preliminary experiment, because the number of samples of the localities represented, and the special conditions of the fruit, were not such as to give completely decisive results. Next season the test will be arranged in such a manner as to work on numerous good and large samples from various localities in the State.

We are also indebted to Mr. Geo. C. Roeding for six larger samples, produced at the Fancher Creek Nursery at Fresno. The first samples received from Fresno consisted of five varieties, one of which (name unknown) had been picked November fourth. The others were the Pendulina, Nevadillo blanco, Manzanillo, Atro-violacea, while the sixth sample, of the Rubra, was picked on February 5, 1891. Their condition was as follows:

Pendulina.—In fair condition only; some fruit dried and beginning to spoil; maturity far advanced.

Nevadillo blanco.—In fair condition, but overripe.

Manzanillo.—In fair condition; some dried olives; generally overripe.

Atro-violacea.—In good condition and at the right degree of maturity for warm climates.

No name.—In fair condition and overripe. This olive resembles somewhat the Italian Cerasola, but is a little larger.

Rubra.—In very bad condition; damaged by frost; maturity at right degree for warm climates.

From Mission San José was received also a sample of Nevadillo blanco, gathered January 13, 1891. It was in rather good condition, but the maturity was a little passed.

Of all the above samples except the Rubra, oil was made by the usual and practical method, in order to have a small quantity for testing its character.

Observations on the Oils Obtained.

On March 13, 1891, I made the following observations on the oils obtained:

FROM FRESNO.

Atro-violacea.—Condition thickish, not clear; color yellowish brown; odor not pronounced; taste rather greasy and coarse. It seems to be slow in clearing. General quality fair.

Nevadillo blanco.—Condition fluid, clear, but not yet bright; color light golden; odor rather pronounced; taste a little greasy, otherwise agreeable and delicate. It clears rapidly. General quality fine.

Pendulina.—Condition thickish, not clear; color yellowish brown; odor pronounced; taste somewhat greasy but agreeable. It will take long to clear. General quality good.

Manzanillo.—Condition very fluid, bright, and transparent; color fine golden; odor

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uggestive of unsoundness; taste very slightly rancid, otherwise delicate. Gen-
ity a rather good oil, clearing quickly. This sample was very small, and it was
le to keep it well.
ue.—Condition clear but not yet bright, rather fluid; color fine light golden;
nounced, but not altogether pleasant; taste slightly greasy and rank. General
a common oil, but clearing quickly.

FROM MISSION SAN JOSÉ.

lo blanco.—(This oil was made two months after those from Fresno.) Condition
almost clear; color rather deep golden; odor of fresh olives; taste, oil too young
e judgment, but promises to become a very fine sweet oil.

n the above observations it appears that olives from the country
Fresno, like those from warm countries generally, produce a thick-
deep tinted, inclined to be "greasy," and therefore not easy to
Moreover, when made in larger quantities, this oil will not clear
kly as did our small samples. The Nevadillo blanco yields the
among the varieties from Fresno, but it is still inferior in qual-
ne same from Mission San José, which, although made two months
romises to clear before or almost at the same time as the other one.
der to remedy the defects that oils made from olives growing in
limates are apt to have, the fruit ought to be gathered when still
sh and only just beginning to change its color toward maturity.
ruit would always produce an oil which, on account of its
taste, would have the same acceptance as that obtained in
climates. If the olive grower cares more for quantity than for
, the olives should be gathered when black and still firm; but in
should this degree of maturity be passed, because the oil from
uit would be of inferior quality, and sometimes also the quantity
be diminished.

ollowing table shows the analytical results obtained by Assistant
rom the different samples received at this laboratory. Column 1
he proportion by weight between pits and flesh in the fresh fruit.
n 2 shows the proportion in which pits and flesh may be made to
ute to the oil product when fully extracted. Column 3 gives the
e percentage of oil contained in pits and flesh. Column 4 finally
ne result of the "iodine test," much relied upon for the purity
mercial oils, as hereinafter explained:

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Partial Analysis of Some Samples of California Olives and Oils.

Variety.	Locality.	Date of Picking.	1 Proportion of Pits and Flesh in Fruits.		2 Percentage of Oil in Whole Fruit Yielded by		3 Percentage of Oil Contained in Fresh		4 Iodine Absorption.	
			Pits.	Flesh.	Pits.	Flesh.	Pits.	Flesh.	Oil from Pressing.	Oils Extracted by Carbon Bisulphide.
Manzanillo	Fresno	Nov. 4, '90	13.0	87.0	.53	19.23	4.1	22.1	80.2	76.5
Manzanillo	Berkeley	Jan. 30, '91	16.0	84.0	.51	21.38	3.2	25.45		76.8
Pendulina	Fresno	Nov. 4, '90	14.8	85.2	1.04	17.40	7.0	20.5	82.6	77.7
No name	Fresno	Nov. 4, '90	17.6	82.4	.88	16.63	5.0	20.2	80.2	73.4
Atro-violacea	Fresno	Nov. 4, '90	23.7	76.3	1.19	13.78	5.0	18.1	83.2	80.7
Nevadillo blanco	Fresno	Nov. 4, '90	17.5	82.5	.16	12.02	6.6	22.0	84.5	86.6
Nevadillo blanco	Mission San José	Jan. 13, '91	24.0	76.0	1.06	23.94	4.4	31.5	86.5	72.5
Nevadillo blanco	Berkeley	Jan. 7, '91	25.0	75.0	1.05	22.72	4.2	30.3		83.2
No. 10 in row	Berkeley	Jan. 7, '91	30.5	69.5	1.34	18.00	4.4	26.0		80.3
No. 2 in row	Berkeley	Jan. 7, '91	36.5	63.5						
Redding Picholine	Mission San José	Jan. 8, '91	29.0	71.0	1.88	21.87	6.5	30.8		73.5
Mission	Mission San José	Jan. 8, '91	23.5	76.5	.94	19.07	4.0	24.9		81.0
Rubra	Fresno	Feb. 5, '91	19.5	80.5	.80	17.69	4.1	21.97		74.2

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Proportion of Pit to Flesh.

rst column, exhibiting the proportion of pit and flesh contained
ruit of the different varieties, shows a maximum of 87 per cent
in the Manzanillo from Fresno, and a minimum of 63.5 per
No. 2 (seedling) from Berkeley. Conversely, the percentages of
re 13 for the former and 36.5 for the latter. Between the
illo from Fresno and that from Berkeley there is a difference of
nt, both in pit and flesh; this is doubtless due to the growth of
ier in irrigated lands.
ame can be said for the differences existing between the Nevadillo
esno and that from Berkeley and Mission San José. Summarily,
eties represented could be arranged as follows in regard to small-
pit and largest amount of flesh: 1, Manzanillo; 2, Pendulina;
dillo blanco; 4, no name (Cerasola?); 5, Rubra; 6, Mission; 7,
lacea; 8, Redding Picholine; 9, No. 2 (seedling).
determinations, which will be continued next season on all
ble varieties, are very important, because they show especially
inds are most suitable for pickling purposes, for which the finest
est olives with the smallest pits are required.

Quantity of Oil.

ext determinations were made with the object of ascertaining
ntity of oil contained in the different varieties.
those represented in the above table, only the Atro-violacea
esno and those from Berkeley showed exactly the right degree
rity for oil-making; hence, the results obtained cannot be taken
senting exactly the respective practical values of the several
However, with the exception of the Redding Picholine from
San José, the maturity of which was very far advanced, the
rieties give results which may be considered approximate.
these determinations, taking into consideration the degree of
y of the olives, it appears that the Nevadillo blanco from Berke-
Mission San José contains more oil than the same from Fresno;
the latter locality the Manzanillo has produced a little more oil
e Nevadillo, but the Manzanillo from Berkeley contains more oil
at from Fresno.
ninimum of oil product is shown by the Atro-violacea from
which was the best conditioned sample received from that

extremely probable, therefore, that these consistent differences
the Fresno olives and those from the other localities are mainly
he growth of the former on flat and heavily irrigated ground,
to produce watery fruit with relatively little oil, particularly
ottom water lies near the surface.
respect to the *quantity of oil* contained in them, these varieties
refore, according to these tests, be arranged as follows:
resno.—1, Manzanillo; 2, Nevadillo blanco; 3, Rubra; 4, Pendu-
no name (Cerasola?); 6, Atro-violacea.
Iission San José.—1, Nevadillo blanco; 2, Mission. The Redding
ne cannot be taken into consideration on account of its very
d maturity.
Berkeley.—1, Nevadillo blanco; 2, Manzanillo; 3, No. 10 seedling.

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If we consider the quantity of oil that the *pit* may yield, we find t largest percentage in the Pendulina and the smallest in the Manzanil both from Fresno; and. glancing at the oil yield of the pits of the ot varieties, we may conclude that it will be a more or less important c sideration, according to the purposes that the oil-maker has in view, according to the special conditions of his locality.

Quality of Oil.

According to European experience, the oil-maker who intends produce oil of the highest quality must avoid, in its extraction, grinding of the pits. The kernel contains an oil of inferior quali which becomes rancid quickly and will deteriorate the fine oil from pulp. An exception may exist in the case of varieties which, like Mission, have abortive kernels.

Mr. Sommer, formerly Assistant in the Chemical Department of University, reports that in April, 1885, he had the opportunity working a small amount of Mission olives, and found that only 2.4 cent of the pits contained plump and well developed seeds. The oth contained either no seed or an imperfect one. All of the seeds, g and bad, were ground to a pulp in a mortar, and extracted with et The proportion of seed oil to pulp oil was thus found to be as 1 to showing that in making oil from the Mission olive no good purpos subserved by crushing the pits at all if it can be avoided.

The crushing of the pits may, of course, be avoided by the use adjustable crushers, which crush the pulp while allowing the pit to p intact.

In this manner oil of very high quality is obtained. Practically, very small quantity of oil yielded by the pits may be neglected, beca this loss will be largely repaid by the higher price at which superfine can be sold. This loss, moreover, concerns only the first pressing, the pomace can then be passed again through the mill in order to gr the pits, and to have a homogeneous paste with the residues from pulp. This paste at the second pressing will give a common oil edible quality, which would find a market at a lower price.

I would not now advise making a third quality of oil from the cake, because, considering the high price of labor in California, and fact that the uses to which the product could be put are well suppl by other oils (especially cotton-seed oil), the practice would not be p itable. The extraction of this inferior grade of oil may become pr ticable when the production of olives becomes large enough to furn large quantities of oil cake at a low figure, in which case factories the special purpose of extracting this inferior quality might be profita established.

In considering the results of our experiments, the conclusion is t so far, among the varieties mentioned, the Manzanillo seems to be best pickling and the Nevadillo the best for oil. The latter vari which, compared with the others, has been recognized as a very g bearer, and able to flourish in climate not very favorable to it, ough be propagated more than has been done so far.

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Tests of Purity—Iodine Absorption.

ast column in the table shows some determinations on the absorption" by the oils obtained by pressing or by chemical on, in order to know if this method could be properly applied to adulterations in California olive oil.

ding to different authors, the ratio of iodine absorption by olive vary from 79.7 to 88, while most chemists do not admit more .5 as a standard, and consider as adulterated every oil which hat limit.

naximum of iodine absorption by our pressed oils was 86.5, and obtained by extraction with carbon bisulphide 86.6. All the ls obtained by chemical extraction showed the iodine absorption an that of the same oils when obtained by pressing.

annot, therefore, rely implicitly upon this method for discovering dulterations in California oils, and must extend the limit usually d for this factor (84.5) at least up to 86.6 for pure oils.

g 88 as the extreme upper limit, it should be mentioned that a number of samples of oil sent us by producers and others, the minimum of iodine absorption was found to be 81.1, while he highest figures were 89.2 and 92.9. Accordingly, these two might be considered as adulterated, but as yet we reserve our nt in the premises.

ew of this uncertainty it will be well to mention here a simple e method by which adulteration with cotton-seed oil (most used teration) can quickly be discovered. It was devised by Prof. i, Director of the Agricultural Station at Florence, Italy. It n officially adopted in the chemical laboratories of the Italian Houses. This method serves to reveal the presence of cotton- in all seed oils, and even in cod liver oil. It may be thus briefly d:

coholic solution of nitrate of silver is made in the following way:

silver	1 gram.
t 98 per cent	200 cubic centimeters.
sulphuric") ether	40 cubic centimeters.
d	1 decigram.

ner solution is also made of:

cohol (fusel oil)	100 cubic centimeters.
a (rape-seed) oil	15 cubic centimeters.

eaction is made in the following way: To ten cubic centimeters l to be tested add one cubic centimeter of the silver reagent and c centimeters of the solution of colza oil in amylic alcohol; stir and divide the mixture so obtained into two equal parts; warm for a quarter of an hour at the boiling point of water, and e with the other half to see if there has been any change of color. of any addition of cotton-seed oil, a dark brownish-red coloration obtained.

ding to the author the same result may be obtained without lza oil, but he employs it in order to obtain always a uniform on. As can be seen, this method is very simple and within any intelligent operator.

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IMPORTATION OF OLIVE VARIETIES.

The following varieties of olives were imported from the highly reputed nursery of R. Pecori, of Florence, under the auspices of Prof. E. Bechi, the Director of the Agricultural Station at Florence, Italy; they were received February, 1891:

1. *Bella de Spagna.*—Its oil is very fine, but it is generally used for pickling.

2. *Leccino.*—On account of its hardiness, ought to be propagated in those regions frequently subject to damage by frost. The fruit is pretty large and fleshy, but not rich in oil; it is, however, a heavy bearer.

3. *Olivo piangente* (weeping olive).—This beautiful variety is somewhat delicate, therefore it requires mild regions, where it will be a good bearer. Its fruit yields a very agreeable and sweet oil, but it is also good for pickling purposes.

4. *Santa Caterina.*—Bearing large fruit; very fine for pickling.

5. *Infrantoio.*—One of the best olive oil varieties from Tuscany; large bearer.

6. *Correggiolo.*—According to Professor Caruso, is the same as the Infrantoio.

7. *Morinello.*—This is widely cultivated in Tuscany, because in stands cold weather and the action of the winds very well. The fruit contains more flesh than the Infrantoio, but the oil is not so fine.

8. *Ascoli.*—Bearing large fruit; very fine for pickling purposes; of high value, both for Italian and foreign markets.

These trees are now growing finely on the grounds of the station at Berkeley, and will be propagated as rapidly as possible for distribution to the sub-stations, and thereafter to olive culturists at various points within the State.

OLIVE-OIL ADULTERATION.*

By L. Paparelli.

In the trade we find many kinds of olive oil, the tastes and the qualities of which depend, within certain limits, upon many circumstances, such as the variety from which the oil was obtained, the manner and the time at which the fruit was picked, the methods in use in the oil factory, etc., all of which are natural differences.

Oils are mixtures of several substances furnished by nature, and the process of elaboration of which is in large part unknown. So we must not be surprised if, in the analytical test, the reactions are not always distinct for the same oil, although given as characteristic and sure.

Olive oil consists of a mixture of "glycerids:" palmitin, stearin, olein; and we may consider that the first two are in the average proportion of 28 per cent, and the third 72 per cent.

The oils that frequently are added to olive oil are the oils of cotton seed, sesame, poppy, rape seed, and peanut. Other oils also are used for adulteration of olive oil.

Therefore, when we receive an olive oil claimed to be pure, we will have to solve the following questions:

Is it a pure olive oil? Is it adulterated with cotton-seed oil? Or is it adulterated with oils from other seeds?

* Part of a paper read before the meeting of the Olive Growers Association, San Francisco, July 8, 1891.

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swer such questions the examination of both the physical prop-
nd the chemical reactions of the suspected oil is necessary; and
some cases one or two tests may be sufficient to enable us to
ce an opinion, in most cases we must submit the oil to *all* the
cognized at present as characteristic, and only from the whole
esults obtained can we decide with certainty on the purity of

Tests of Adulteration.

hysical characters of each sample must be first examined, viz.:
lor, and taste. The latter two always give useful indications
g the purity of an olive oil, but they can be appreciated only
xpert. The specific gravity should also be determined, although
nost seed oils does not differ much from that of olive oil. Those
which the specific gravity is materially different are generally
l for adulteration.

oint of fusion and of solidification of the free fatty acids, the
heat, the electric conductivity, the capillarity coefficients, etc.,
il may be taken into account in the examination; but all these
l properties differ so little in the different oils, that although
e in distinguishing each from the other, they are useless when
are mixed.

vill give special attention to the chemical reactions now known
acteristic and quite decisive for most cases.

e Absorption.—The iodine number is the percentage of iodine
d, while cold, by a hundred parts of oil. About .03 grams of
issolved in 10 cc.* of pure chloroform and mixed with 20 cc. of an
c solution of iodine and chloride of mercury: the liquid is kept
es well closed for about two hours in a cool and dark place. In
e conditions are kept another 20 cc. of the same iodine solution
cc. of chloroform, and its strength is determined by a deci-
solution of hyposulphite of soda. The differences between the
y of the hyposulphite employed to destroy the color of the iodine
which has been in contact with the oil and that needed to
the color of an equal quantity of iodine solution unmixed with
esents the iodine absorption of the oil itself.

as been stated already in Experiment Station Bulletin No. 92,
ng to different authors the ratio of iodine absorption by olive oil
ry from 79.7 to 88, while most chemists do not admit more than
a standard, and consider as adulterated every oil which passes
it.

his test cannot be altogether relied upon, because iodine absorp-
s been found higher for pure olive oils, as may be seen in the
entioned bulletin. In Italy, also, Professors De Negri and Fabris
und for pure olive oil higher iodine absorption (87.9).

causes which produce this variability, so far as studied, are the
g:

e riper the olives from which the oil has been made the higher
dine absorption.

d and rancid oil has generally a slightly lower number.

e method of oil-making has also its influence; that is, oil made
e pulp only, shows a slightly lower iodine absorption than that

* centimeters.

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obtained by grinding pulp and pits together; oils extracted by chemic solvents have a lower iodine absorption than the same obtained pressing; oil obtained from the pits always shows a higher iodi absorption than that extracted from the flesh.

4. It seems the largest influence is due to the olive variety fro which the oil is made; in fact, some varieties always show a very hig figure.

On the whole, then, the conclusion is that high iodine absorptio even up to 88, is not always indicative of adulteration with seed oil but may be on account of the quality of the oil itself. Therefore, order to determine with certainty whether an olive oil is or is not mix with seed oils, we must take into consideration the other chemical tes which give more definite results.

Bechi's Reaction.—(For this test, see the description given in Expe ment Station Bulletin No. 92, above.)

Hauchecorne's Reaction.—Stir six grams of oil briskly with two gra of pure nitric acid, and warm the mixture for about twenty minutes a bath of boiling water. Olive oil treated in this manner becomes p colored, or acquires the yellow color—proper to fine olive oil in case was dark colored before being tested. On the contrary, it becom yellowish-orange or reddish-brown when mixed with seed oils.

Brulle's Reaction.—To 10 cc. of oil add one decigram of dry albu in fine powder, and 2 cc. of pure nitric acid. Warm carefully this mixtu until the acid begins to boil, and then stir well, continuing to wa till the albumen is completely dissolved, which occurs in a few secon Genuine olive oil at this point becomes almost colorless, and after cooli it becomes more or less turbid, but of a fine yellowish straw color, whi it retains for a long time; after twenty-four hours it becomes complet solid and remains of the same color. On the contrary, when seed o are present the coloration is from yellowish-orange to reddish-brown the time of the dissolution of the albumen by heating, and genera they do not solidify.

Heidenreich's Reaction.—Into a porcelain capsule with flat bottom p enough pure concentrated sulphuric acid to make a surface as large a silver dollar, and on it let fall five or six drops of the oil to be test Observe carefully the coloration produced during three minutes at t points of contact of the oil with the acid; this coloration in pure oli oil should be yellowish or greenish-yellow; and in seed oils from y lowish-orange to reddish-brown. This reaction in many cases mig produce an error; it is therefore necessary not to rely on that test alo

Baudouin's Reaction.—A very characteristic reaction of sesame is the property it has of turning crimson-colored a solution of sugar concentrated hydrochloric acid. The reagent is prepared by dissolvi one gram of sugar in 100 cc. of hydrochloric acid. To one volume this solution add two volumes of the oil to be tested, and stir briskly some time. After some minutes of settling, the aqueous liquid wh separates is uncolored if no sesame oil is present, but in the contr case is colored crimson, more or less intensely.

Schneider's Reaction.—Colza, or rape-seed oil, like other oils of crucifers, contains sulphur; therefore, when carefully treated with sil nitrate it produces a black coloration, due to the formation of sulph of silver. For this test dissolve the oil to be tested in twice its volu of ether, and stir the liquid with about 5 cc. of a saturated alcoh

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of nitrate of silver. After twelve hours allowed for settling in place, a black coloration or precipitate is obtained in case of the e of oil from crucifers, especially after the evaporation of the

bove represent the best tests known for ascertaining the purity oil; but the greatest care in the preparation of the reagents and perations are required, otherwise the most skillful chemist may the determination. The correct appreciation of colors also considerable experience.

FIBER PLANTS FOR CALIFORNIA.

The Production of Ramie.

By E. W. Hilgard.

(*University Experiment Station Bulletin No. 90.*)

evival of interest in the culture of ramie that has followed the cement of the apparently successful tests made of a new decorti- nachine at the late Mechanics' Fair, renders it desirable to some of the main points of this industry as bearing upon its ion to California. The great beauty of the fiber and the almost ed commercial demand for it when brought into the market in e form; its adaptation to a great variety of soils and climates; production; the perennial nature of the plant that renders its very inexpensive; last, but not least, the possibility of easily ning the productiveness of the soil by a return of the "trash," ramie near to cotton (when the seed is returned) as bearing ntly on the soil's native fertility; and, finally, the relatively high nd light weight of the merchantable product when shipped—all lvantages concur in rendering the culture of this fiber plant y desirable wherever it is feasible. That it has not become more pread, and has not largely superseded the much more costly and ive culture of flax, is mainly due to the difficulty of accomplish- separation and cleaning of the fiber by a machine sufficiently to compete with the scraping by cheap hand labor, which, in nt, is the habitual and the only mode of supplying to commerce hina grass"* fiber.

difficulty arises from the presence in the bark of a gummy sub- hat encases the fiber, and from which it must be thoroughly freed r mechanical or chemical processes, or by both combined, before e worked.

essentially different plans have been pursued in the effort to lish this. One is the "wet" process, in which (as in the Orient) n stalk is operated upon, requiring appliances somewhat dis- m those used in the preparation of hemp or flax fiber; while in y" process the mechanical operations are substantially the same in the case of our familiar fiber plants, but modified to suit a

* oss inappropriateness of the latter name may render it desirable to repeat here. nefit of those to whom the subject is new, that the ramie plant is a large, sting- d-leaved nettle, and therefore belongs to a family of plants of which many other supply valuable fibers.

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specially difficult case. In either mode the mechanical treatment
to be followed by a more or less intense chemical one, for the remo
of the last remaining greenish gum from the silky fiber before the la
is ready for the spinning machine. The latter, in view of the great len
of the ramie fiber, should be of the kind adapted for "line" spinni
but of course it is quite feasible to convert the fiber into tow or sh
length material, resembling long-staple cotton. Some of the ol
machines have done this; and if, as is now stated, such material
find purchasers among the workers in wool and cotton at remunerat
prices, there is little difficulty about its production in large quantit
But one of the merits of the ramie fiber—its resemblance to silk-
thus grievously impaired, and it may be fairly said that no machine
process that does not produce the fiber in a condition for line spinn
can claim to have achieved the problem of making ramie as profita
a crop as it can be.

The "wet" process seems to have had the best success in the count
whose climatic conditions involve a perennially moist atmosphere,
where a thorough drying of the stems is therefore difficult. The pr
ciples upon which the work is done are, in general, the breaking of
more or less brittle and "brash" stems, fresh from the field and strip
of their leaves, by means of a suitable modification of the ordin
breaking process as applied to dry stems of hemp, etc. The stem
but undecorticated fiber, usually rolled into bands for the better pre
vation of its parallelism, is then dried, partially or wholly by artifi
heat, so as to render the gum and bark brittle enough to be removed
subsequent beating and combing.

Sometimes this mechanical after-treatment has been omitted
the stemless crude fiber passed directly into the alkaline bath (mos
of common or caustic soda), which is always required to remove the
of the gummy matter, but a too prolonged action of which will imp
the strength of the fiber. The latter is then ready for a final combi
and for spinning with or without preliminary bleaching.

The "dry" process differs from the "wet," in that the stalks—cut
the time when their oldest portion is just turning color from green t
brownish tint—are first allowed to dry in the field, if this can be do
and when fully dry are at once subjected to the action of breaking,
of beating, or combing machines, that remove stalk and bark, with g
in proportion to their perfection, leaving again the crude fiber more
less ready for the alkaline bath, as in the wet process.

It will readily be understood that the *dry* mode of working is
adapted to a dry climate, in which the stalks and gummy bark bec
so brittle that the breaking and beating is effective to a degree whic
would be impossible to attain in moist climates, like those of Louisi
or Guatemala, except by artificial heat, which, as stated, is there
generally used in connection with the *wet* process. Hence, the
mode of working promises exceptional advantages where—as in
interior of this State—the dryness of the summer air is proverbial.
dry process also possesses the advantage that each machine can be k
running continuously on practically uniform material; while in the
mode of treatment the plants must, in a large field, either be worke
very different degrees of maturity, or else the crop must be attacked wit
large number of machines, in order to secure uniformity of the produ
after which the machines will lie idle. It would therefore seem,

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general principles, that where the dry process is climatically offers advantages over the other method, provided an equally chantable product can be turned out.

t discussing the merits of the different machines now offered ers as a guarantee that their crop, when grown, will be con- nto a merchantable article, and of which I, personally, am not t fully informed, it should be said as regards the *culture* of t by actual trial it has been found to be readily feasible in all valley regions of the State, so far as the successful growth of is concerned; but that it will, doubtless, prove most profitable long growing season, combined with irrigation, permits of hree or four cuts annually. In the Kern Valley there is little in getting *four* cuts, of good size and quality, and the same is true on the stronger soils as far north as Fresno, and south- he valley of South California. In the Sacramento Valley *three* doubtless, be obtained, at least when irrigation is employed, urally moist land. At Berkeley, and elsewhere on the imme- st, *two* cuts (the second usually a small one) are all that can be on; but in warm valleys of the Coast Range, doubtless from ree full crops, according to the supply of moisture and the of the soil, may be looked for.

llowing table shows the record of crops of the white-leaved *rtica nivea*) harvested during four years on the Berkeley ntal grounds, the last of seven. No manure was used on the it was reset in 1888 in order to equalize the stand which had aired by the distribution of roots; hence, doubtless the low n that year and a later cut. The size of the plots, of which d is here given, is eighteen by thirty-four feet, or about one rst of an acre. The green plants were weighed with the hich are estimated at about one half of the "live weight." talks were weighed practically leafless:

lts of Experimental Culture of Ramie on the University Grounds, Berkeley.

ate of Cutting.	Plot.	Yield—Pounds.	Yield Per Acre.	Percentage, Dry to Green.
FIRST CROP.				
24	1	576½ green	40,032	
16	1	491 green	34,861	27.6
		135½ dry	9,621	
	1	624 green	44,304	21.3
		133 dry	9,443	
9	1	763 green	54,173	16.0
		122 dry	8,662	
9	2	623¾ green	44,269	18.8
		117 dry	8,307	
ECOND CROP.				
ber 31	1	174 green	12,354	
mber 21	1	210 green	14,910	35.2
		74 dry	5,254	
mber 21	2	102 green	7,241	37.2
		38 dry	2,698	

ing for the years during which the observations of the product account of frequent calls for samples) not as full as during the same average ratio as to the weight of the two crops and

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the percentage of dry stalks yielded, we find that the product has beer an average rate of about nine thousand pounds of dry stalks per acre the first cut, and about five thousand two hundred and ten pounds the second. This gross weight of course would be somewhat less in dry air of the interior of the State; but the figures show that on str soils the expectation of eighteen to twenty thousand pounds per a where four cuts can be made, is not extravagant. The minimum pr uct from dry stalks is estimated to be 15 per cent of raw merchanta fiber. Upon these data an approximate estimate of the crop, and of financial outcome in the several climatic regions of the State, may based.*

It is hardly necessary to remind any intelligent farmer that o *strong* soils can be expected to produce, in one season, a crop of ten t of dry stalks of *any* kind, and that few can continue to produce s crops for many years without substantial returns to the land, no ma how fertile originally; but there is no reason why the offal of the ra crop—the leaves and the stalk trash—should not be regularly retur to the soil. The leaves can be, and are usually dealt with by stripp the stalk on the ground, leaving them where they grew. As to stalks, it is true that with three or four cuts per season it will be d cult to deal with the large mass of refuse by spreading it on the stub although in the more northerly portions of the area of cultivatio may be desirable to use this material for protection against frost. as the return must either be made, or fertilizers furnished, the pro mode of procedure will be to make compost heaps of the trash and t render it less bulky, and convenient for spreading on the stubble a the last cut. This, in the case of strong soils, is all that will be requi to keep up production for a long time, although the raw fiber sold r resents a larger proportion of the soil's plant-food than in the cas cotton, in which the return of seed and stalk will maintain product indefinitely on any soil capable of yielding a profitable crop. When returns are made, ramie will prove even a more exhaustive crop tha cotton when the seed is not returned; and those engaging in its cult had better understand from the outset that they can "rob the soil" w ramie even more effectually than with wheat.

On the strong, black, adobe soil of the Berkeley experimental p where purposely no return or fertilization of any kind has taken pl

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* Mr. Goncet de Mas, who grows the ramie at Padua, Italy, planted it twenty by tw inches, or sixteen thousand plants per acre, and gives the following as his results:

First Year.—Cut 39,700 pounds, of which 19,800 pounds were leaves. On drying, the st weighed 3,970 pounds, which, by decortication, yielded 883 pounds of fiber.

Second Year.—First cutting	75,386 pou
Second cutting	69,757 pou
Total stems and leaves	145,143 pou
Green stems	72,571 pou
Dried stems	14,514 pou
Fiber	2,604 pou
Third Year—The plants thinned out to forty by forty inches.	
First cutting	90,640 pou
Second cutting	87,640 pou
Total green stems and leaves	178,280 pou
Green stems	88,990 pou
Dried stems	17,600 pou
Fiber	3,520 pou

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of 1890 was fully as large as any previous one within the four which weighings had been made. Owing to the constant call ts, the ground has never been solidly occupied by the crop; but the year in which the plot was reset in spring, with half the the product was nearly up to the average, so rapidly do the iller and spread.

g the strongest soils in the State are those containing more or alkali," and as these are mostly valley lands, the question of laptation to ramie culture is important. Experiments have hat while ramie is a little more sensitive to alkali than alfalfa, tand all but the strongest spots, *provided the alkali is not of the kind*, viz.: carbonate of soda; and as the conversion of black nto "white" is easily effected by the use of proper doses of or gypsum, it may fairly be said that with this proviso, ramie grown in alkali lands available for little else, since the growing a cannot be carried beyond a limited point with profit to the r, on account of its relatively low value and heavy weight in rtation. The main reason why ramie will grow in alkali ground me as in the case of alfalfa: because it shades the ground, and he evaporation, going on through the leaves of the plants instead e surface of the soil, will not accumulate the noxious salts around crowns so as to corrode them. But it must not be forgotten il the plants fully shade the ground, the rise of alkali in the must be prevented by thorough tillage, otherwise damage may n that the outermost roots suffer and the spread of the plants is ..

ainst alfalfa, ramie also possesses the advantage that, as it is pagated from seed (in the field at least), but by the division and ing-out of plants or their roots, the difficulty of obtaining a n account of the rotting of the seed by the alkali, does not exist. , then, as the successful and profitable growth of the plant is ed, there need be little doubt in the valleys of the central and n parts of the State, so soon as the processes for marketing the ll be an assured success.

Composition of the Ramie Plant.

By M. E. Jaffa.

(*Experiment Station Bulletin No. 94.*)

lletin No. 90 ("Fiber Plants for California," June 23, 1891) nention is made of the exhaustion of the soil by the production e. The object of the present investigation is to show the actual s of soil ingredients withdrawn by the different parts of the nd to point out the great necessity of returning to the soil the nd stalks after decortication.

riments on a small plot upon the University grounds, and on a rger scale by M. Goncet de Mas, at Padua, Italy, have proved good soils, where from three to four cuts can be made annually, l will be about ten tons of dried stalks per acre. M. Goncet de the third year after planting, obtained from two cuts nearly nine dried stalks. We are told by Mr. McAfee, of Bakersfield, that fiber is produced when three, instead of four cuts, are made

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annually. The total yield of the three will not differ materially fr that of the four cuts, the weight of each cut in the former case be proportionately heavier. The tables given below, showing the to amounts withdrawn from the soil, are based upon these maxim figures.

Separate analyses were made of the ashes of the leaves, stalks wi out bark, and bark, *i. e.*, cuticle and fiber, including gum. The cuti and fiber were analyzed together, because, while the leaves and sta can be readily returned to the soil, it will hardly be feasible to do with the cuticle and gum; and, as stated above, our present object is ascertain what can and what cannot be given back to the soil.

Chemical Composition of the Plant and its Ash.

It is found that five tons of wet or fresh stalks are equivalent to of dry.

We find that the leaves constitute about 30 per cent of the dried pla the decorticated stalk 51 per cent, and the bark 19 per cent. Of latter, nearly 15 per cent is raw fiber, containing 30 per cent of g thus making the percentage of pure fiber in the plant as grown b about 11.

Referred to stalk, *without leaves*, as 100, the results are as follo Decorticated stalk 73 per cent, whole bark 27, of which 6 is cut and 21 decorticated fiber with gum. Thus the proportion of pure fi referred to stalk alone is about 15 per cent.

Table No. 1 shows the proximate composition of the different pa of the plant, and also the results of the analyses of the ash of several parts:

TABLE NO. 1.

Proximate Analysis of the Ramie Plant.

	Whole Plant.	Stalk.*	Bark.†	Leave
Water	81.36	81.75	80.91	
Organic matter	17.25	17.68	18.78	
Ash	1.49	.57	.31	
Totals	100.00	100.00	100.00	1
Ash in dry substance	7.950	3.120	1.620	1
Nitrogen in fresh plant	.258	.146	.210	
Albuminoids in fresh plant	1.612	.912	1.312	

*Stalk without bark.
†Including fiber and gum.

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Analysis of the Ash.

	Whole Plant.	Stalk.	Bark.	Leaves.
,O)	11.82	37.79	32.58	4.18
O)	2.35	8.15	8.77	.54
	30.87	17.32	22.28	34.74
	7.89	10.58	11.64	7.02
de and alumina	2.41	2.95	.84	2.35
of manganese	.17	.35	.18	.12
c acid (P_2O_5)	7.29	16.38	12.64	4.72
acid (SO_3)	2.26	3.46	3.68	1.88
	33.01	1.56	5.24	42.42
	2.43	1.87	2.75	2.55
	100.50	100.41	100.60	100.52
s of oxygen due to chlorine	.50	.41	.60	.60
	100.00	100.00	100.00	99.92

spection of the figures representing the percentage in the ash of le plant shows that *lime* is the most abundant ingredient, being r cent; next comes *potash* with 11.82 per cent, while that of *ic acid* is only about one fourth that of lime, viz., 7.3 per cent. e ash of *leaves*, also, by far the most prominent ingredient of od is lime, forming a little more than one third of the whole ash and phosphoric acid amounting to less than 5 per cent The predominating element in the ashes of the *stalk* and *bark*, contrary, is *potash*, being in the former case more than 37 per d in the latter almost one third of the weight of the ash, thus ng the heavy draught made on the soil in this respect. The ges of phosphoric acid in the stalk and bark are nearly three half and two and one half times, respectively, that contained eaves. Lime, while not present in such large quantities as in es, still occupies a very prominent place among the ash ingredi- ll parts, the stalk containing 17.32 per cent, and the bark 22.38

nsidering the relative values of the different ashes, it must not tten that, although the figures given represent pounds per hun- the *ash*, it will require a very much smaller quantity of the make one hundred pounds of ash than is the case with either bark. Thus, about five hundred pounds of dried leaves will e hundred pounds of ash: but three thousand two hundred of dried stalks and six thousand two hundred pounds of bark necessary to produce the same amount of ash.

Fertilizing Value of the Ash.

ble No. 2 are shown more clearly the fertilizing values of the the different parts of the plant; it presents the amounts of ingredients actually withdrawn from the soil per acre. It is ed for a crop of ten tons of dried stalks per acre, and, of course, he yield is not so large, the draught upon the soil is proportion- s.

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TABLE NO. 2.

Amount, in Pounds, of Soil Ingredients Withdrawn from One Acre Annually, by Four C of Ramie Yielding a Total of Ten Tons of Dried Stalks and Four and One Quarter T of Leaves.

	Whole Plant—14¼ Tons per Acre.	Stalk—7¼ Tons per Acre.	Bark—2¾ Tons per Acre.	Leaves—4¼ Tons p Acre.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds*
Potash (K_2O)	251.98	155.99	27.86	6
Soda (Na_2O)	50.14	33.63	7.52	
Lime	657.82	71.77	19.14	56
Magnesia	168.27	43.68	10.01	11
Ferric oxide and alumina	51.43	12.16	.71	3
Manganese oxide	3.57	1.45	.20	
Phosphoric acid (P_2O_5)	155.70	67.71	10.86	7
Sulphuric acid (SO_3)	48.56	14.53	3.17	3
Silica	704.25	7.06	4.48	69
Chlorine	51.85	2.50	7.79	4
Nitrogen	369.70	105.85	57.75	20

A consideration of the data given in the table proves to what alarming extent the soil would be depleted by a continuous culture ramie when nothing is returned; as no soil, no matter how rich or nally, could long withstand such a great strain upon its resources.

The total amount of mineral ingredients withdrawn by a single c (four cuts) is two thousand one hundred and forty-three pounds, wh must be considered as permanently removed when neither the lea nor the stalks are used as fertilizing materials. The draught made lime is about six hundred and fifty-eight pounds, on potash two hu dred and fifty-two pounds, phosphoric acid one hundred and fifty- pounds, and on nitrogen to the extent of three hundred and seve pounds, per acre. Of the potash about three fifths, or one hundred a fifty-six pounds, is contained in the stalks, more than one quarter, sixty-eight pounds, in the leaves, while the bark and fiber, the o production aimed at, contains a little above one tenth, or twenty-ei pounds, of the total amount.

The leaves contain nearly 87 per cent of the total lime taken from t soil, that found in the stalk being about 10 per cent, and that in t bark 3 per cent.

Of the total phosphoric acid withdrawn, the leaves absorb almost per cent, or seventy-seven pounds, the stalk 43 per cent, or about six eight pounds, while only 7 per cent, or ten and eighty-six hundred pounds, is found in the bark.

The depletion of the soil in nitrogen is greatest through the leav which have more than 55 per cent of the total, or two hundred and pounds; about 29 per cent, or one hundred and six pounds, is found the stalks, while in the bark there is only 15 per cent, or about fif eight pounds.

It will thus be seen how very small is the proportion of plant-f withdrawn by the bark and fiber, as compared with that by the lea and stalks; and since the fiber is beyond comparison the most valua product sought, it is obvious that its continuous production should, ab all, be assured.

The ingredients first to be exhausted by such a continuous cult would in all probability be phosphoric acid and nitrogen, owing to

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t so many of the soils of this State, notably those of the valleys, ich in potash and lime, are very poor in phosphoric acid, and nes in nitrogen. In sections where irrigation can be practiced, and lime will frequently be supplied to the soil in considerable ies by the irrigation waters, for analyses of the latter show them in appreciable amounts of these elements. Lime occurs in them orm of gypsum (thus also replacing to some extent the sulphuric eded by the plant) and carbonate of lime; the potash is generally s sulphate. Notwithstanding this, the soil's supply would soon nished, and the replenishment would have to be made by fertil- ntaining high percentages of *all* the ingredients which go to make t-food. No "special" fertilizer would answer the purpose.

the other hand, the *leaves* and *stalks* are returned to the soil, the of mineral matter withdrawn is, comparatively speaking, very being only about twenty-eight pounds of potash, nineteen of even of phosphoric acid, and fifty-eight of nitrogen per acre. A soil could withstand such a small demand for a considerable of time without showing an appreciable diminution of crops; and er fertilizers become necessary, it will probably be found that in ia, phosphoric acid and nitrogen are the substances to be supplied. he decorticated stalks *only* are returned to the soil, as might be e if the *leaves* were sold to paper mills, as has been suggested, out sixty-eight pounds more of potash, five hundred and sixty- f lime, seventy-seven of phosphoric acid, and two hundred and itrogen per acre are taken away from the soil than would be the re they, with the stalks, given back to the land.

her or not it would pay to sell the leaves is a financial question ng on the prices obtained for them, and upon that which would be paid, sooner or later, for fertilizers used instead.

ld the *stalk* not be used as a fertilizer, then the amount of potash ently removed from the soil would be increased by one hundred y-six pounds, that of lime by seventy-two, phosphoric acid by ght, and that of nitrogen by one hundred and six pounds, quan- rming, with the exception of lime, a large percentage of the total matter withdrawn.

gards the *manner* of returning the "offal" of the ramie plant to , the following paragraph from Bulletin No. 90 will be of interest: s hardly necessary to remind any intelligent farmer that only oils can be expected to produce, in one season, a crop of ten tons stalks of *any* kind, and that few can continue to produce such r many years without substantial returns to the land, no matter tile originally; but there is no reason why the offal of the ramie he leaves and stalk trash—should not be regularly returned to . The leaves can be, and are usually dealt with by stripping the the ground, leaving them where they grew. As to the stalks, ue that with three or four cuts per season it will be difficult to ith the large mass of refuse by spreading it on the stubble, h in the more northerly portions of the area of cultivation it desirable to use this material for protection against frost. But return must either be made, or fertilizers purchased, the proper f procedure will be to make compost heaps of the trash, and thus it less bulky, and convenient for spreading on the stubble after

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the last cut. This, in the case of strong soils, is all that will be requir to keep up production for a long time, although the raw fiber sold re resents a larger proportion of the soil's plant-food than in the case cotton, in which the return of seed and stalk will maintain producti indefinitely on any soil capable of yielding a profitable crop. When returns are made, ramie will prove even a more exhaustive crop th is cotton when the seed is not returned, and those engaging in its cu ure had better understand from the outset that they can 'rob the so with ramie even more effectually than with wheat."

COMPARISON WITH OTHER CROPS.

A comparison of the amounts of mineral ingredients withdrawn the ramie with those removed by other crops, will more forcibly sh how a soil can be robbed by its continuous culture without returns bei made. This is shown in Table No. 3.

Fiber Plants Compared with Ramie.

Of all the fiber plants ramie stands first as regards depletion of t soil of plant-food, a result which was to be expected from the grea mass of the plant harvested, since from three to four cuts can be ma of the ramie, while only one each of hemp and flax is made. Taki average crops, hemp is second in total amount of ingredients remov cotton third, and flax fourth. Thus the total quantity of potash th is withdrawn by ramie is about two hundred and fifty-two pounds, th by hemp one hundred and one pounds, by flax forty-four pounds, a thirty-five pounds by cotton. The corresponding figures for lime a ramie six hundred and fifty-eight pounds, hemp one hundred and thir one pounds, flax twenty-three pounds, and cotton forty-four pounds.

As regards the total amount of phosphoric acid withdrawn, the ra is somewhat altered, in that flax *with seed* causes a severer drain in th respect than hemp, the figures being: ramie one hundred and fifty- pounds, flax forty-one pounds, hemp thirty-three pounds, and cott twenty-three pounds. It will be seen from a comparison of the abo figures that when nothing is returned to the soil the depletion is l with cotton, so far as phosphoric acid and potash are concerned, th with either of the other fiber plants, and that the total amount remov by a good crop of ramie is more than the combined weight withdra by flax, hemp, and cotton, illustrating again the impoverishing effect this plant on the soil.

The total amount of nitrogen withdrawn by ramie is three hundr and seventy pounds, which is about six times that removed by he and five times that by flax. The data at hand for cotton are insuffici for comparison of the *total* quantity carried off, but the seed takes aw from the soil by far the greater part of the whole amount of nitrog required by the cotton plant; hence it will be readily seen that ra has a much more exhaustive effect on the soil than has cotton, w reference to this costly ingredient.

When the refuse materials for the different plants are returned to soil, even then the ramie still stands first in depleting the soil of nit gen; in fact, it removes fifty-eight pounds against an insignific amount by the fibers of the other plants.

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	Potash	Soda	Lime	Magnesia	Br. Oxide of Manganese	Iron and Alumina	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Nitrogen
RAMIE—												
Leaves, 4.25 tons	68.13	8.99	566.91	114.58	1.92	38.56	77.13	30.86	692.71	41.56	1,641.35	206.10
Stalk (without bark), 7.25 tons	155.99	33.63	71.77	43.68	1.45	12.16	67.71	14.53	7.06	2.50	410.48	105.85
Bark (cuticle and fiber), 2.75 tons	27.86	7.52	19.14	10.01	.20	.71	10.86	3.17	4.48	7.79	91.74	57.75
Whole plant, 14.25 tons	251.98	50.14	657.82	168.27	3.57	51.43	155.70	48.56	704.25	51.85	2,143.57	369.70
HEMP—												
Leaves, 1,975 pounds	56.46	.47	98.62	11.55	.....	.....	18.70	4.46	11.36	.34	.....	.....
Stems, 3,000 pounds	44.44	1.40	24.86	5.51	.....	.....	12.91	1.63	.75	.51	.....	.....
Clean fiber, 1,000 pounds	.40	.08	7.22	.65	.....	.....	1.61	.05	.49	.01	.....	.....
Whole plant, 5,975 pounds	101.30	1.95	130.70	17.71	.....	.....	33.22	6.14	12.60	.86	.....	62.74
FLAX—												
Straw, 1,800 pounds	23.04	2.43	13.63	3.60	.18	.76	7.87	4.02	1.60	2.26	59.39	18.00
Seed, 1,724 pounds	20.60	1.19	5.80	9.75	.35	1.45	32.00	.07	.29	.04	71.54	56.54
Fiber, 600 pounds	.13	.30	3.27	.30	.....	.24	.72	.18	.34	.05	5.53	.....
Whole plant, 4,124 pounds	43.77	3.92	22.70	13.65	.53	2.45	40.59	4.27	2.23	2.35	136.46	.....
COTTON—												
Leaves, 400 pounds	7.99	4.40	15.03	2.50	.....	2.38	4.22	5.84	3.58	2.75	48.49	.....
Stems, 1,200 pounds	9.17	3.65	10.58	3.56	.....	.75	4.49	1.99	1.71	2.54	38.44	.....
Seed, 800 pounds	8.99	1.15	3.07	4.00	.....	.52	9.74	1.11	.51	.48	29.37	29.20
Burs, 400 pounds	7.42	4.59	14.16	3.19	.....	2.66	3.57	6.88	7.40	2.14	52.01	.....
Lint, 400 pounds	1.69	.42	1.20	.46	.....	.12	.52	.24	.08	.36	5.09	.....
Whole plant, 3,200 pounds	35.26	14.21	44.04	13.71	.....	6.43	22.54	16.06	13.08	8.27	173.40	.....
WHEAT—												
Grain, 20 bushels	7.85	.14	.72	2.57	.....	.22	11.90	.34	.24	.02	24.00	24.00
Straw, 3,000 pounds	36.07	1.54	10.32	3.95	.....	1.54	7.90	6.59	146.26	7.87	222.04	18.00
Whole plant, 4,800 pounds	43.92	1.68	11.04	6.52	.....	1.76	19.80	6.93	146.50	7.89	246.04	42.00
SUGAR-BEETS (Fresh)—												
Roots, 40,000 pounds	152.00	24.00	16.00	24.00	.....	3.00	36.00	12.00	8.00	12.00	287.00	60.40
Tops, 32,000 pounds	235.44	198.48	208.08	171.60	.....	13.68	80.16	68.64	36.96	49.68	1,062.72	113.00
Whole plant, 72,000 pounds	387.44	222.48	224.08	195.60	.....	16.68	116.16	80.64	44.96	61.68	1,349.72	173.40

NOTE.—The data for the above table have, with the exception of that for ramie, been taken from the various station reports and bulletins.

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If the seed, in the cases of cotton and flax, is sold in place of retur ing it to the soil, then the flax and ramie bark carry away about th same amount of nitrogen, while cotton takes only one half that quan tity.

If the soil is replenished by the "offal" or refuse products of th several plants, viz., returning all but the fibers, then, as regards *potas* the quantity removed by ramie is 28 pounds, by cotton less than pounds, .42 of a pound by hemp, and .13 of a pound by flax. Were th seed in the case of cotton used otherwise than as as fertilizer, even the the amount would be only about eleven pounds, which is considerabl less than one half of the figures for ramie. In other words, for th withdrawal of the same number of pounds of potash carried off by single crop of ramie yielding ten tons of dried stalks per acre, the would be required sixteen crops of cotton, sixty-six of hemp, and tw hundred and fourteen of flax. The number of pounds of *lime* necessar for the ramie is 19, for hemp a little more than 7, for flax about 3.2 and 1.2 for cotton; or, making as before a comparison by crops, we ha the result that one crop of ramie is equal in exhaustive power to 16 cotton, about 2.5 of hemp, or to 6 of flax.

The *phosphoric acid* of the soil is drawn upon to the extent of pounds for ramie, 1.6 for hemp, .72 for flax, and .52 for cotton, showin in regard to this as other ingredients, that ramie causes the greate strain on the soil.

When flax is grown for fiber *and* seed, then the relation between and ramie, so far as soil exhaustion is concerned, is materially change inasmuch as that when the seed is sold, the potash permanently remov is twenty-one pounds (in place of .13 of a pound when the seed is use in fertilization), or more than two thirds of the quantity required b the ramie. The phosphoric acid is also very much increased, an instead of being less than one tenth, is then *three times* the amoun withdrawn by ramie. In this case flax has a much more exhaustiv effect on the soil than has ramie, because, although it uses up less lim and potash and about the same quantity of nitrogen, it draws muc more heavily on phosphoric acid, which, as has been previously state is found in the soil of this State only in small proportions, there bein on the contrary very generally an abundance of lime and potash.

Wheat vs. Ramie.

Comparing ramie to wheat, we find from the table that when the leav and stalks of the former are returned to the soil, the potash withdraw by the bark is not nearly so much in amount as in the case of whea being about 28 pounds for ramie as against 44 for wheat. The phosphor acid is not much more than one half that of wheat crop, the figures bein 11 against 20. Hence, as regards these two elements of plant-foo wheat impoverishes the soil to a greater extent than does ramie, whe stalks and leaves are returned.

Just the opposite conclusion is to be drawn when we compare th lime and nitrogen contents, particularly so in reference to the latte which is taken from the soil to the extent of 106 pounds in the case ramie, as against 42 for wheat; the proportion for lime is as 19 is to pounds.

If nothing of the ramie "offal" is used as fertilizing material, the

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l is robbed much more effectually than is done by wheat, and in
ios indicated by the following figures: Potash, 252 to 44; phos-
acid, 156 to 20; lime, 658 to 11; nitrogen, 370 to 42.

Sugar-Beet vs. Ramie.

data given in the table for the sugar-beet will be of special inter-
the farmers who are now raising them, or who contemplate so

amount of potash removed by a twenty-ton crop of roots is 152
, and by the tops 235. Of phosphoric acid, 36 by the roots and
nds by the tops. A still greater difference is shown in the case
, the roots drawing on the soil to the extent of 24 pounds as
195 for the tops, or more than eight times as much. The nitro-
the tops is nearly double that found in the roots, as indicated by
ires 113 and 60.
reful consideration of the above will at once show the great bene-
e derived from, and the absolute necessity of, returning to the soil
ar-beet tops; which, fortunately, is almost always done in practice.
readily seen from the table that the cultivation of the sugar-beet,
he tops are *not* returned to the land, will impoverish the soil in
in a much shorter time than is the case with ramie, even when
ire plant is removed.
egards the other costly ingredients, phosphoric acid and nitrogen,
oe seen that the ramie plant as a whole draws much more heavily
than does the beet, and in the case of lime the difference reaches
portion of nearly three to one. When, however, all but the bark
ned in the case of ramie, and in that of the beets all but the root,
ount of potash taken away from the soil by beets is 152 pounds,
al to about five times that by the ramie. The difference is not
arked in the case of lime, ramie requiring 19 pounds and the
6. The same can be said concerning the nitrogen, for which
ent the figures are 106 and 113; whereas, the phosphoric acid
beets, 36 pounds, is nearly three and one half times that of the
It thus appears, that when in beet culture the tops are returned,
ught upon the soil is on the whole much heavier than in the case
e, as it requires so much more potash and phosphoric acid, while
ount of nitrogen is about the same in each.

Fruits vs. Ramie.

g to the insufficiency of the data at hand a comparison of ramie
e fruits, as regards the total amount of mineral matter withdrawn
different crops of the latter, cannot be made; but those quantities
compared which are permanently removed in each case, as shown
le No. 4:

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TABLE No. 4.

Quantities of Soil Ingredients Withdrawn by Various Fruit Crops Compared with Ramie Ba and Fiber.

FRESH FRUIT.	Total Ash, Pounds.	Potash, Pounds.	Phosphoric Acid, Pounds.	Nitroge Pounds
Grapes—Crop of 10,000 lbs. per acre	89.00	50.00	15.20	17.
Oranges (California)—Crop of 20,000 lbs. per acre	86.40	40.14	10.60	36.
Pears—Crop of 20,000 lbs. per acre	66.00	36.00	10.00	12.
Plums—Crop of 30,000 lbs. per acre	87.00	51.60	13.20	167.
Apples—Crop of 20,000 lbs. per acre	44.00	16.00	6.00	12.
Ramie bark (dry)—Crop of 5,500 lbs. per acre	91.74	27.86	10.86	57.

It will be seen, as regards total mineral matter, that while that the ramie does not differ materially from that of grapes, oranges, plums, it has a trifle more than double that of apples and about or and four tenths times that of pears. Its content in potash is not muc more than one half that found in grapes and plums, considerably le than in the case of oranges and pears, but is one and three fourth times that of apples. The phosphoric acid percentages are almo identical in the ramie bark, orange, and pear; grapes and plums co taining, respectively, 50 and 30 per cent more than does the rami while apples have only about 60 per cent of that amount.

In nitrogen-contents ramie stands second to plums. Grapes car off a little less than one third, oranges about three fifths, and pears an apples somewhat more than one fifth of that removed by the ramie.

On the whole, then, ramie culture, when all "offal" is returned, fairly comparable to the less exhaustive fruit crops; but without suc return it must be classed among the most exhaustive cultures know

FLAX FOR SEED AND FIBER.

By E. J. WICKSON.

(*University Experiment Station Bulletin No. 90.*)

Occasional efforts have been made during the last fifteen years establish the manufacture of linen fabrics in California by those clain ing to be practically acquainted with the industry elsewhere, but th proprietors of such enterprises have abandoned the undertakings b cause of the alleged lack of interest among local capitalists. Wheth this is the true reason for the failure to establish flax spinning in th State or not, we do not pretend to state.

It has been frequently stated that the production of flax for both se and fiber is not feasible, and our farmers who have grown flax for se have therefore abandoned the thought which has frequently arisen their minds, of gaining something for their flax straw as well as f their seed crop. It seems likely that an erroneous impression has th been engendered, for there are recent authoritative statements to th effect that not only is the production of both seed and fiber from th same plant not impracticable, but that "by far the larger part of th flax grown the world over, is for the double crop and double profit both the seed and fiber."* We are also assured that "it is possible

*New York "Dry Goods Economist," October 18, 1890.

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or both seed and fiber, though the fiber will be coarse, naturally, ly fit for the lower classes of manufacture."†

possible, then, that even in growing flax for seed, as now prac- n this country, the fiber could be made a source of income, pro- the straw was not disintegrated, as in the prevailing mode of ing. It is also possible that by selecting a better variety of flax ommonly grown for seed, and by sowing more thickly, so that owth of the lateral branches on the main stem is measurably ed, there might be secured a fiber product vastly better than is btained, and therefore fitted for a higher class of manufactures. rocedure might result in a lessened production of seed by the lual plant, and perhaps a reduction in the aggregate yield per n fact, in our experiments with flax varieties, we find that the uropean fiber varieties yield much less seed than the variety nly grown for seed in this State.

ay be concluded, then, that though to grow flax both for seed and equires closer thought and greater effort than are usually given to x crop, and that to make the straw available to manufacturers s some investigation and investment on the part of the flax , the current claim that one cannot grow flax for both seed and not necessarily true in the nature of the case, nor in the experi- the greater number of the flax growers of the world.

rder to minister to the oft-recurring demand from inventors for nia-grown flax straw for trial in their machines and processes, furnish seeds to growers who desired to experiment, we secured urope, years ago, four of the best fiber flax varieties, and have them from year to year on the experiment grounds of the Berke- tion. They have attracted much attention from visitors for their ul, straight, tall growth of stem and bright, clear color. The of the four varieties has been quite similar, as shown by the of 1890:

VARIETY.	Sown.	Germinated.	Bloomed.	Harvested.
	April 12	April 23	June 5	July 24
seeded	April 12	April 23	June 2	July 24
owered	April 12	April 23	June 2	July 24
	April 12	April 23	June 5	July 24
ia	April 12	April 23	June 10	August 4

European fiber varieties are thus shown to require a shorter g period than the California seed variety. The fiber varieties ed one third longer in straw than the Californian; they branched d produced much less seed. Accurate weighings of straw and ave not been secured hitherto, because the plots were invaded ime to time to furnish specimens for exhibition and for experi- fiber extraction by local inventors. This year careful weighing made.

ugh these flaxes have aroused considerable interest here in the r stated, there has been no result in local fiber treatment that is mentioning. Seed was sent to Washington Territory, and straw

rt on flax, hemp, etc., by C. R. Dodge, United States Department of Agricult-

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grown there was sent to European flax manipulators, who returned very favorable report. On April 29, 1890, we received a circular reque addressed by Mr. S. S. Boyce, President of the Boyce Fiber Compa of New York, to the various experiment stations of the United Stat asking for samples of flax straw, which he agreed to work for fiber a report results. Mr. Boyce did not describe his process, but it is sta by Mr. Dodge (in his report to which allusion has already been mac to be "a process for cleaning flax without first submitting the straw the process of retting, thereby obtaining the fiber at once." Such process naturally would be more attractive to the flax grower, for t time, labor, and water required in retting are all probably of high cost and more difficult to command in this State than in other regio where flax is grown.

The New York "Dry Goods Economist" of October 18, 1890, contain a description of the working of the flax straw sent to Mr. Boyce fr this station, with engravings of the several bundles as received by h The following is a condensed tabular statement, which we compile fr the data in the article referred to:

Weights of Seed, Straw, and Fine Fiber from California-Grown Flax Varieties.

VARIETY.	Gross Weight.	Seed.	Straw.	Fine Fil
Yellow-seeded	19	7	12	
Russian	16	6	10	
Royal	15	6	9	
White-flowered	15	7	8	
California	14	7	7	

Comments upon the experiments are, that the Russian and Ro seemed to be best, both for seed and fiber. The California gave mu the largest yield of seed, and the seed was very large and plump, l the fiber was coarse and weak.

Of the general results of the experiment, the "Economist" says:

"There is no tow by this process of retting. The natural color of t straw was very light; that of the fiber almost perfectly white in ea sample. The total yield of the fiber, 23 per cent of the weight of t straw, was rather a light yield of fiber, but very fine. The yield of fil is greater when the straw is not overripe. The samples treated h been allowed to get riper than required for either seed or fiber.

"The results of this trial are of interest as showing clearly the supe ority, from a textile point of view, of the flax varieties which this stati has introduced to this coast over the common variety which is gro for seed. Whether it is possible to realize more by the attempt to p duce both seed and fiber here, and to substitute one of these variet for the one commonly grown, is an industrial question depending up manufacturers and capitalists for solution. The farmer cannot affo to produce a crop of any kind until a market is assured."

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GRAPES AND OTHER CULTURES.

New Persian Grapes.

By L. Paparelli.

long been known that the valley of Persia produces some of t grapes known to the world. None of these grapes have been to America until recently, but after some correspondence, Prof. an Deman, the well known pomologist of the United States ent of Agriculture, succeeded in procuring stock. He writes s, under date of December 2, 1890, to Professor Hilgard:

e pleasure of sending to you at the Central Station, seventy-seven grapevines, prise seven varieties, and are sent under numbers instead of names, because been some mistake made either by Minister E. Spencer Pratt, or the person ed them at the propagating houses of this department. I, however, feel sure natter will be straightened up, and that in due time I will be able to give you names. In the meantime you may propagate them according to your judg- me are not in very good condition, but I think all will grow. They are among t kinds of grapes grown in Persia.

ve just sent to the station at Tulare, eleven varieties of the grapes received ame source, and for which we have the correct names, as follows: *Askaree*, *White Shahanee*, *Chavooshee*, *Hutab*, *Dizmar*, *Khallilee*, *Black Shahanee*, *Rish canee*, *Razukee*, and *Shiraz*. I sent them there direct, because I thought you ly want them there, but if I am mistaken, you can order them just where you . The same varieties have been quite generally distributed throughout the rust that they will all grow, and that in the future something may come of at delightful home of the grape. A few of the vines are in rather poor condi- se they were propagated quite late in the spring from single eye cuttings. Of re are eleven vines; of No. 21, twelve; of No. 22, ten; of No. 23, fourteen; of ht; of No. 25, ten; of No. 26, twelve vines.

ooted grapevines were reshipped from Tulare to the Central where they were potted and placed in the propagating house. being pushed as fast as possible, and a fairly large stock will to be sent out next year.

Grapes from Italy.

By L. Paparelli.

(*Experiment Station Bulletin No. 91.*)

ew of the kinds of European grapes peculiar to Italy have been to California. "Crabb's Black Burgundy," identical with the Refosco," was one of the first of the type. John T. Doyle, Esq., l the *Nebbiolo*, the *Barbera fina* of Asti, and the *Freisa* of Italy. Later came the *Aleatico*, *Provinante*, such white grapes *ignanga* and *Pizzutello*, and perhaps five or six other Italian of reputation.

University has now obtained cuttings of forty-eight kinds of wine and table grapes. They are from the vineyards of Count da, of Turin, a famous authority on grapes and wines. They g rooted in pots, from single joints, so as to increase them as ossible; some have been grafted on older stock. In a year the will have complete sets, and a year later a general distribution nade of the Italian as of the Persian varieties.

s asked what is the especial value of this class of grapes (the , the answer is, that good dry wine which keeps well cannot ted under conditions of greater heat when northern grapes are

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cultivated. Both Italy and Spain make dry wines. The warm pa of California must depend more upon the Spanish and Italian varieti These varieties, and also the Persian, are intended for the dry inter valleys, the warmer foothills, and the southern counties.

The varieties obtained can be briefly described as follows:

Aspiran noir.—A French table grape, making a delicate and bri wine; rather thin for market.

Cipro nero.—Comes from Cyprus; makes one of the best wines kno there. Late in ripening; a good table grape.

Cesanese nero.—The variety that is grown extensively on the Rom Campagna; makes a good and strong wine.

Grisa di Piemonte.—A leading late wine and table grape of the Pi mont districts.

Negro amaro.—Another good bearer; a wine grape.

Negro dolce.—Said to be the same as *Dolcetto nero.*

Paga-debito.—A black grape good for wine.

Monica.—One of the best of the Sardinian wine grapes.

Neiretta.—Black; heavy bearer; favorite Piedmont sort.

San Gioveto.—From Tuscany, and blended with such sorts as *Frei Barbera*, and *Canajolo.* Used in many of the best Tuscan wines.

Tadone.—From Piedmont; wine strong and dark.

Bolgnino.—A wine grape from Saluzzo.

Neretto grosso canavese.—A very acid and dark wine grape.

Croattina.—A large, round black grape of Piedmont; best in d soils.

Danugue.—The same as the Nice variety, *Gros Guillaume;* large, la

Antibo.—A Saluzzo variety.

Quagliano.—A very fine table grape for light soils. Might prove excellent shipping grape.

Ocru di bove.—Sardinian variety, late, black, large berry.

Bermestia violacea.—Another large-berried Piedmontese kind.

Pelaverga.—A reddish-black Saluzzo kind, used for table and fo special sweet wine.

Croetto, Erbalus di Caluso, and *Bellino* are all Piedmontese variet of reputation.

Corbeau is already known in California.

Chenin noir is a good French variety.

Two Tuscan varieties of promise are *Mammolo toscano*, which ha violet bouquet, and *Malvasia di Brolio.*

Barbarossa di Finalborgo is an excellent keeper, and used for ta and wine.

Favorita, said to be the *Vermentino di Liguria*, is a good white w and table variety.

Vernaccia sarda, from Sardinia, is one of the heaviest bearers kno

Olivette de Cadenet, from France, seems the same as *Crujidero.*

Catarattu a la Porta.—This is an exceedingly promising variety, of those used in the wines of Marsala. It comes from Sicily; la yellow grape, late in ripening, and heavy bearer.

Picpoule is another French grape, much planted in Italy.

Pis de chêvre, another French kind, went to Italy by way of Hunga

Torok goher is a Hungarian variety; also at home in Italy.

Malvasia de Rovasenda is a Sicilian seedling, named for Count Ro senda; a red-black grape, of good character.

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sia de la Cartuja is a Spanish grape, of the same type as pre-
white in color.
ra di Gattinara is peculiarly liable to *oidium*; otherwise a fine

retta is a raisin grape of the Piedmont; used also for wines.
lero is a very late white grape for table; Spanish origin.
are several other grapes, of which little or nothing is yet

Culture of the Black Wattle.

From notes by the late W. G. Klee.

portant source of tannin is found in several Australian acacias,
roup termed Wattles, viz.: *A. decurrens*, the Black Wattle, and
ntha, or Golden Wattle. The products of these, under the name
sa bark, find their way to the London market, where the price
£8 a ton. The facility with which acacias are grown here along
is well known, and naturally recommends them as shelter trees
rchards, if it were not that they are said to be breeders of scale
This, however, would not be an objection to raising them for
of the bark, as the scale hardly affects the tree seriously until
ge enough for use. The cottony cushion scale, now conquered
edalia, was the chief source of trouble. The danger has been
ted; the acacias should be more generally planted. In any
anter can depend on home-grown trees, and such difficulties can
entirely obviated. Baron Ferd. von Müller, the distinguished
has urged the planting of wattles in their native home, ever
caused the bark to be analyzed, nearly a score of years ago.
his the first time the planting of the wattle has been publicly
nded in California. The reason for doing so again is that we
failed to hear of any large enterprise in this direction.
llowing estimate of the cost of a plantation of a hundred acres
from the report of the Board of Inquiry, appointed to investi-
subject in Australia:
acre planted with Black Wattles, ten feet apart, would carry
dred trees, and at the end of the fifth year would yield fifty-six
f matured bark; stripping every third tree, three hundred and
ree tons would be obtained from a hundred acres; this, at £4,
ve for the first stripping, £1,332.
sixth, or following year, a similar number of trees would be
the bark having increased in weight, say fourteen pounds, the
l yield of the second crop would make four hundred tons, at
on, £1,600.
seventh year the remaining trees would be stripped, from which
eater increase would be obtained, say four hundred and eighty
£4 per ton, £1,920.
gregate yield during the first eight years would be one thousand
dred and fifteen tons, £4,852.

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The expenses are calculated as follows:

Rent of a hundred acres, at six shillings per acre per annum	
Plowing one hundred acres in drills, ten feet apart	
Sowing of wattles and actual cultivation, seed included	
Pruning the trees, taking off useless growth, only necessary for two years, at ten shillings per acre	
Supervision for eight years, nominal, say £50 per annum	
Incidental and unforeseen expenses	
Interest on the whole amount expended during eight years	
Actual cost of stripping and carting	
Total	£
Profit balance, exclusive of improvements on supplementary savings	

Though this estimate requires considerable modification in its spe terms, it does most likely not exceed the probable. No doubt one h dred acres could be bought for the £250, or $11 an acre; land suit for this purpose exists in large quantity in different counties, such Santa Cruz and Monterey, and others, in regions partly covered v pines, where the soil is too poor for any kind of fruit or grain.

In the Australian estimate the expectation is to raise new trees f seed to replace those cut down. This, perhaps, would not be nee as the wattle here almost invariably sends up sprouts from the ro which grow with greater rapidity than the seedlings; such, at leas the case in good soils. It will also be seen that in this estimate allowance is made for the value of wood, which, from trees eight y old, would be considerable.

Acacia decurrens is comparatively seldom seen in California, *A. dealbata*, or Silver Wattle, generally known by the name of *A. mollis* in the nurseries, being the one most commonly planted.

The two are easily distinguished by the time of bloom; *dealb* blossoms in January, *decurrens* in June. They can also be distinguis when in fruit, the Black Wattle being characterized by having the p contracted between the seeds, making it next to impossible to get latter out without breaking the pod altogether. *Dealbata*, on the c trary, which is also known by the bluish-white hue of the foliage, the seed lying rather loosely in the pod. This latter species, so of planted around San Francisco Bay, and confounded with the other, according to Baron Von Müller, very valuable for fuel, but not r enough in tannin for tanning purposes. As regards the *A. pycnant* it is known that it will grow particularly well in poor soil, but it i rather small size for profitable tanbark production.

DISTRIBUTION OF SEEDS AND PLANTS, AND DONATION RECEIVED.

By E. J. Wickson.

The distribution of seeds, plants, scions, etc., has been regularly c ried out since the inception of this branch of work early in the hist of the Berkeley station. In the report of 1885–6, summaries were gi of earlier distributions, and in subsequent reports general allusi were made to the work. It is intended to give, herewith, a tabular sh ing of the extent and cost of distribution and an outline of the ma rials transmitted. By including the years which have elapsed since

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report, data are secured for an interesting comparative show-

eeds and plants distributed are chiefly grown at the Berkeley Occasionally, when wide trial is desired of some lauded novelty, own material is supplemented by purchase. The plan is to issue, , announcements (*vide* University Bulletins, Nos. 61, 76, 81, 84 of the material which it is desired to place in the hands of perimenters, inviting each to choose for himself that in which st interested, and to require applicants to remit money enough the cost of packing and postage, as nearly as it can be esti- This rule is enforced, because it prevents application from those uld thoughtlessly apply for whatever costs nothing, and it interest enough on the part of the applicant to prompt a faith- of the material sent him. This plan of distribution has worked l, as is shown by the hundreds of reports, from which data have npiled for the different parts of this report; and to these specific ons, elsewhere, the reader is referred for fuller information con- the plants included in the summaries below:

Number of Plants and Cuttings Distributed.

NAME.	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.	Total.
ack wattle	185					185
	201	102				303
	205					205
	224		804			1,028
nor		985				985
ak		268	535			803
alm		188			56	244
		92				92
berry		212				212
		46				46
		108				108
h oak				210	260	470
ple				280	128	408
					136	136
ts—Esparto grass	70	20	60	50	10	210
ealand flax	50	130	125	75	90	470
	270	160	130		90	650
nts—Australian salt bush		10	480			490
blue-grass roots			1,320		7,050	8,370
amboo	49	374	146	48	49	666
				306	195	501
e roots					285	285
Grape	3,156	3,120	3,420	460	330	10,486
rry	965		4,120	1,190	1,140	7,415
				1,340	810	2,150
						560
ls	5,375	5,815	11,140	3,959	11,189	37,478
ruit (number of orders)	133	28	24	19	28	232

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Weight, in Ounces, of Seeds Distributed.

NAME.	1886-87.	1887-88.	1888-89.	1889-90.	1890-91.	Tot
Cereals—Wheats	1,008	1,360	.....	1,584	960	4
Barleys	.....	992	.....	736	1,856	3
Oats	.....	704	.....	.....	832	1
Ryes	.....	.....	.....	.....	768	
Buckwheat	.....	56	.....	.....	.....	
iber—Flax	924	352	.....	172	104	1
Cotton	.....	.....	.....	892	328	
Jute	.....	.....	.....	68	20	
Forage—Grasses—Millet (*Milium multiflorum*)	126	59	.....	86	36	
Schrader's brome	568	99	404	408	176	1
Hungarian brome	.....	168	608	160	88	1
Japanese wheat	.....	.....	156	382	96	
Tall oat	.....	.....	159	.....	72	
Japan clover	86	.....	.....	.....	.....	
Snail clover	.....	294	160	148	76	
Kaffir corn	122	.....	440	400	.....	
Yellow millo maize	.....	140	.....	.....	.....	
Black medic	.....	82	128	.....	.....	
Esparcette, or sainfoin	.....	.....	1,524	364	192	2
Tagasaste	.....	55	272	.....	.....	
Hairy-flowered paspalum	.....	.....	134	54	22	
Jersey kale	.....	.....	178	86	82	
Garden—Corn	.....	1,023	1,724	.....	.....	2
Peas	.....	38	338	196	.....	
Pumpkins and squashes	.....	221	200	.....	.....	
Beans	.....	.....	590	.....	224	
New Zealand spinach	.....	.....	41	.....	40	
Beets	.....	.....	.....	202	202	
Trees—Black wattle	84	210	202	.....	59	
Sumac	.....	22	.....	.....	.....	
English oak acorns	.....	.....	624	.....	.....	
Sundry—Pyrethrums	114	272	230	113	80	
Quinoa	80	37	.....	.....	.....	
Chuna	.....	39	.....	.....	.....	
Tobacco	.....	250	.....	.....	221	
Dyer's madder	.....	.....	13	6	.....	
Chapman's honey plant	.....	.....	.....	112	80	
Totals	3,112	6,473	8,125	5,669	6,614	2

Extent of Distribution.

	1886-87.	1887-88.	1888-89.	1889-90.	189
Number of applicants supplied	631	589	818	471	
Orders filled by mail	428	427	704	377	
Orders filled by express	197	324	290	184	
Post Offices reached	252	247	356	230	
Express offices reached	111	175	171	121	
Counties reached	48	45	50	50	

*The number of counties in 1890 was 53.

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Financial Statement.

	1886–87.	1887–88.	1888–89.	1889–90.	1890–91.
Receipts.					
nps, orders, etc., from applicants	$291 70	$475 64	$336 95	$201 80	$244 55
e from Agric. Dept. of University	?*	86 00	73 00	58 00	54 00
ceipts	$291 70*	$561 64	$409 95	$259 80	$298 55
Expenditures.					
naterial for seeds	$23 40	$23 95	$33 59	$27 25	$26 89
naterial for plants	27 03	51 17	46 50	42 20	35 95
artage, etc.	85 33	95 51	65 94	41 55	49 54
	3 70	5 60	7 10	6 85	6 24
	90 25*	228 00	194 75	116 40	150 10
xpense	$229 71*	$404 23	$347 88	$234 25	$268 72
nfilled orders returned to applicants	61 99	157 41	62 07	25 05	29 83
	$291 70*	$561 64	$409 95	$259 80	$298 55

ONS OF SEEDS, PLANTS, ETC., DURING THE YEARS 1888 TO 1891, INCLUSIVE.

1888.

F. Von Müller, Melbourne, Victoria, Australia: Seeds of *Acacia a, A. Sophoræ, Alyxia buxifolia, Billardiera longiflora, Clianniceus, Cordyline Australis, Eucalyptus Gunnii* var., *Notoæa Pisonia grandis, Pittosporum undulatum, P. tenuifolium, P. P. eugenioides, Tecoma Latrobei, Vitex littoralis.*

United States Department of Agriculture, Washington, D. C.: Tobacco, 7 varieties; turnip, 4 varieties; watermelon, 2 varieaskmelon, 3 varieties; cucumber, 3 varieties; squash, 2 varieties; 3 varieties; parsnip, 2 varieties; beet, 6 varieties; onion, 2 varieery, 2 varieties; kale, 1 variety; lettuce, 2 varieties; tomatoes, y; peas, 5 varieties; corn, 7 varieties; sugar corn, 6 varieties; 1 varieties; eggplant, 1 variety; cauliflower, 1 variety; carrot, y; cabbage, 2 varieties; asparagus, 1 variety; Chinese sugar-*orghum vulgare*, var. *saccharatum*); winter wheats, 5 varieties; ariety; buckwheat, 1 variety; rye, 1 variety; cotton, 4 varieties; blue *Vicia velosa, Stipa tenacissima* (Esparto grass), *Spergula maxima, a;* Teosinte (*Reana luxurians*); *Melilotus alba, Abies Nordmannius Laricio* (Corsican pine), *P. resinosa* (red, or Norway, pine), *rosa* (yellow, or bull, pine), *Taxodium distichum* (bald cypress), *lrus decurrens* (California white cedar), *Juniperus Virginiana* dar). Cuttings: *Salix amygdalina Caucasica, S. amygdalina , S. amygdalina latifolia, S. purpurea* X *viminalis, S. rubra, S. s* (Belgian, Rough red, Smooth golden, Rough green, and mixed owing varieties), *S. purpurea, S. purpurea* (wild), *S. hippophaëviminalis nobilis.*

J. Hanna & Co., Sterling, Kansas: Seeds: Sorghum, 9 varieties.

J. M. Thorburn & Co., 15 John Street, New York: Seeds: seedling, Rural New Yorker No. 2; Thorburn's Everlasting er.

abor furnished by the Agricultural Department of the University, of which no account was kept by distribution assistant.

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1889.

From U. S. Department of Agriculture, Washington, D. C.: Seeds: *Lupinus*, winter horse beans and hairy vetch, sulla (*Hedysarum coronarium*), seradella (*Ornithopus sativus*), small pea (*Lathyrus sativus*), giant spurry (*Spergula maxima*), *Lathyrus hirsutus*, bird's-foot clover (*Lotus corniculatus*); an assortment of tobacco seeds, also of imported onions, beets, carrots, lettuce, turnips, squash, radish, cabbage, parsnips, tomatoes, cucumbers, muskmelons, watermelons, peas, beans, and corn. Texas blue grass (*Poa arachnifera*), red fescue (*Festuca rubra*), *Festuca elatior;* vetch (*Vicia sativa*), champion honey plant (*Echinops sphærocephalus*), improved white Georgia collards, new white velvet okra, new Japanese buckwheat, Red Kaffir corn, six varieties of non-saccharine sorghum, grown by A. A. Denton, Sterling, Kansas, for distribution by the department; also, eight varieties of saccharine sorghum.

From Jeane Sisley, Rue St. Victor Monplaisir, Lyons, France: Seeds: *Gladiolus grandanensis*, Dahlia (*gracilis striata*), *Calycotome spinosa*, *Cannas*, *Styrax*, *officinalis*, *Hypericum Canariense*, *Melaleuca* sp. *Nicandra physaloides*, *Ligustrum Chinense*, *Raphiolepis ovata*, *Cotoneuster Simoni*, an assortment of *Iris*, *Euonymus fimbriatus*, *Trachycarpus Fortunei* (Chamœrops), *Rhodotypus kerrioides*, *Ferula Australis*, *Acacia brachybotrya*.

From L. C. Kincaid, Encinitas, San Diego County, Cal.: Seeds of millo maize.

From Dippe Bros., Quedlinburg: Seeds of Kleinwanzlebener beet.

From Mrs. M. A. Boyce, Santa Rosa, Cal.: Plants: *Smilax aspera*, *Libonia floribunda*, or *Benshœnsis*, Jasmine (sp. ?) *Carya*, *Dasylirion serratifolium*, *Agave Balmerii*, *Alœ picta*, *A. zebrina*, *Tecoma jasminoides*, *Swansonia alba*, or *Grayana*, *Peonia arborea*, *Chrysanthemum*, *Mesembryanthemum* sp., *Opuntia*, *Eryobothrya* sp. and one unknown plant from the Sandwich Islands. Seeds: Large *Anona*, small *Acacia* sp.

From S. Frogner, Herman, Minnesota: Two varieties of potatoes.

From Deerbrook, Mississippi: Japan clover seed.

From Delano Moore, Presque-Isle, Maine: Seeds of rutabaga.

From Northrup, Braslan & Goodwin Co., Minneapolis, Minnesota: Seeds of two varieties of peas and cucumbers, and one each of lettuce, beans, watermelon, celery, tomatoes, and pansy.

From D. G. King, San Francisco: Bulbs of *Nerine Japonica*.

From the Government Botanic Garden, Saharampur, India: Seeds of mahwa (*Bassia Latifolia*).

1890.

From U. S. Department of Agriculture, Washington, D. C.: Cuttings of *Salix amygdalina canescens*, *S. amygdalina latifolia*, *S. purpurea X viminalis*, *S. viminalis* (*Merriniana*, *stricta*, *sedanensis*, red rough of *Gallica*, green rough of *Gallica*, high-growing mixed), *S. purpurea Schultzeana*. Seeds from South America: *Jubæa spectabilis*, *Cocos coronata*, *C. humilis*, *C. campestris*, *Phœnix reclinata*.

From W. A. Lawson, Marysville, California: Seeds of *Leucadendron argenteum* (silver tree), acacia from St. Helena, Thorn acacia from New Zealand.

From Jacob C. Bauer, Judsonia, Arkansas: Van Deman strawberry.

From T. V. Munson, Denison, Texas: Eight varieties of apple trees, two of pecans, and sixteen of grapes.

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John A. Salzer Seed Co., La Crosse, Wisconsin: New Governor
tato.
Schuster & Barr, Seattle, Washington: A new strawberry.
Northrup, Braslan & Goodwin Co., Minneapolis, Minnesota: Two
s of corn and one each of barley, millet, celery, watermelon, and

Dr. Thornton, West Ferndale, Washington: Seeds of the wild
apple, Christmas bell, yellow-flowered wattle (*Acacia mimoso-*
an orchid, yellow *Ganoa*, climbing fern, castor-oil plant, Barba-
ide, white-flowered lilac, mimosa from the West Indies, shell
icorice from the West Indies, brush Læviger or rattan, yellow
e, *Zamia*, *Eucalyptus globulus*, *Clematis glycinoides*, *Clianthus* (?),
ya tree, and a few others.
J. J. Rivers, Berkeley, California: Seed of *Pinus Torreyana*,
n Diego County, California.
P. L. C. Sheppard, Sydney, Australia: Seeds of Australian nut
mea elegans, *Lambertia formosa*, *Eriostemon nerifolium*, *Actinotus*
us, *Epacris grandiflora*, *Acacia vestita*.

GRASSES AND FORAGE PLANTS.

By Edward J. Wickson.

duction and distribution of grasses and forage plants suitable to
liar climates and soils of California, have constituted a leading
of work at this station ever since its establishment. Notes of
s in this effort have appeared in previous annual reports, notably
eport for the years 1885–6, which was published in 1887. The
f 1889 contained a brief generalization, indicating a number of
which have given much satisfaction to those who have tried them.
letins announcing seed distributions in 1886 to 1890 (Bulletins
31, 84, and 89) contain notes of those plants which have been
ly commended for trial, and tables, given elsewhere in this
show how great has been the interest in this branch of our work,
w widely we have distributed seeds of those species which seemed
omising. Letters received from those who have participated in
tribution afford comprehensive data for conclusions as to adapta-
nd practical values of quite a large group of plants; and compila-
om the great mass of testimony embodied in these letters will
the basis for this report. Brief extracts from individual reports
en in connection with a brief generalization, because the inquirer
en thus obtain direct local information, which will be of most
alue to him.
to be regretted that the data is imperfect, because correspondents
forget to describe the soils, moisture conditions, and methods of
ion which, in many cases, might govern the results reported;
ere diametrically opposite results are reported from the same
, diversity of local conditions or the personal equation must be
with the discord. Bearing these things in mind, the reader will
to draw many important conclusions concerning the various
rom the testimony presented.
an usually furnish seeds or roots of the plants under consider-

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ation during the months of January and February, and a bulletin issued each December giving lists, terms, etc. Our distribution is experimental purposes only. We do not furnish material for la sowing.

JAPANESE WHEAT GRASS—AGROPYRUM JAPONICUM, VASEY.

This is a grass new to science and to cultivation on this contine Hearing that there was being grown and highly esteemed in New Zeals a grass which had been introduced from Japan, we applied to W. Gol Domain Curator at Auckland, for seed, which he kindly sent us in 18 The plant passed in New Zealand under the indefinite name of "Japan grass." As soon as we secured a growth from the seed sent us by Goldie, we submitted specimens to Dr. George Vasey, U. S. Botanist, Washington, who determined it as a new species, which he will descr as *Agropyrum Japonicum.*

Accounts of the grass from New Zealand describe it as a strong a vigorous grower, stooling rapidly and abundantly, but little affected drought and exceedingly hardy, producing a reasonable growth all year round in the Auckland district. By its growth in our experimen plots, the grass has sustained its New Zealand reputation as a stro growing, drought-resisting grass. We distributed the seed for the f time in 1889, the announcement bringing many more applications than could fill. The grass, however, is a very heavy seeder, and by sow an additional plot we were able to satisfy demands for the seed following year. One plot of Japanese wheat grass sown in Janua 1889, made a good stand, covered the ground perfectly, and yielde heavy crop of seed in August without irrigation. After cutting, the p was given one irrigation and the second growth started at once, and December first was again in full head. It has been wholly unaffec by frosts which have seared more tender grasses. The growth of grass is stocky and leafy but not tall.

Although experiments have not yet proceeded far enough to dem strate its value, the following notes from correspondents clearly port some of its characteristics:

George Simmons, Yreka, Siskiyou County.—Japanese wheat grass did not do very wel

Charles Foulke, Arcata, Humboldt County.—Japanese wheat grass ripened a good c of seed the first summer, and started quickly after the first rains. By the follow February it was twelve inches high, while orchard grass and mesquite (*Holcus lana* were but four inches, for we had a very cold, dry winter. I have seen no grass to ec the Japanese wheat for this climate.

Frederick Werner, Westport, Mendocino County.—Very few seeds of the Japanese wh grass germinated. These plants bore seed, but did not start afterwards. I believe the was too strong for it. It is one mile from the coast, and this was the first year a clearing.

J. M. Addington, M.D., Bartlett Springs, Lake County.—Japanese wheat grass does seem to do well on very dry land without irrigation.

Frank Owen, Zem Zem, Napa County.—Japanese wheat grass is of no great value u dry hill lands, though stock seem very fond of it.

C. F. Shelton, Bangor, Butte County.—Japanese wheat grass does well. The rabbits very fond of it, though. It should be thoroughly tried on dry land in the lower footh

John Isbister, Sweetland, Nevada County.—Japanese wheat grass, sown in January, g two and one half feet high and bore seed without irrigation.

Robert Hastie, Clayton, Contra Costa County.—Japanese wheat grass made rather a p growth the second year from the old roots. It was irrigated until the water supply g out (June 1st).

L. L. Guss, Brentwood, Contra Costa County.—Japanese wheat grass made a good grov

Howard Overacker, Centerville, Alameda County.—Japanese wheat grass came up well spread rapidly on hill land. It headed close to the ground, the head being long, cos and bearded. I don't like it as well for stock as oat grass, or many other grasses.

S. J. Irwin, Fresno.—Japanese wheat grass, sown under a live oak tree, germinated w

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o eaten down by "varmints" that it did not head. I thought during the sum-
it was dead, but when the fall rains came it started up from the old stock and
y. It seems to have the lives of a cat, and I believe it will make splendid pasture
nds.

Weiss, Creston, San Luis Obispo County.—Japanese wheat grass, sown in March
sandy loam, received one good rain after sowing. The plants grew about ten
gh, dried up and died in June.

Vash, Stuart, Santa Barbara County.—Japanese wheat grass did well, growing about
high and producing much seed.

S. Cleland, Mesa Grande, San Diego County.—Japanese wheat grass grew finely
y hillside, until we had an unprecedented hot spell in July, which cooked the
n the trees. This heat burned the grass up completely.

tton, Elsinore, San Diego County.—On sandy loam upland the Japanese wheat
e up and promised well, but never attained much height, and finally dried up
r.

Haffenden, Lakeside, San Diego County.—I had no water for irrigation, and the
wheat grass dried out, so that it made very little growth.

rink, El Casco, San Bernardino County.—Japanese wheat grass sown in March on
y loam, attained a good growth.

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hite, Sumterville, Alabama.—Japanese wheat grass sown in March germinated
it made a good growth; headed out in July at twelve to fifteen inches high. It
ought better than oat grass, and retained a dark green color during a dry spell in
n oat grass was nearly burned up. After two years' experience, I am disposed
nd it highly as a winter grass.

annigan, Pasco, Washington.—The Japanese wheat grass beats the world. It
ier than our bunch grass, stands drought as well, and remains green longer. If
our winter's freezing, which I have not had a chance yet to determine, it will be
se value.

TEXAS BLUE GRASS—POA ARACHNIFERA.

grass is a close relative of Kentucky blue grass (*Poa pratensis*),
s not grown in this State except as a lawn grass; and even as a
ass it is being largely superseded by other grasses which are less
g in their demands for water and work on the part of the grower.
lue grass, though resembling Kentucky blue grass in color and
of much more robust and vigorous habit, takes a much deeper
and is in every way a coarser plant. It is specially commended
outhern States as a good winter grass, starting early, and grow-
, making a winter growth as satisfactory as that of Kentucky
ass in summer, in regions adapted to it.

several ineffectual attempts to get a stand of the grass from seed
from Texas, we secured root-sets from that State in 1888, making
tion of them in that year, as well as securing a good plot upon
ion grounds at Berkeley. The growth during the summer of
s very satisfactory, the plants spreading well without irrigation.
ts have been differently treated; one grown without irrigation,
other watered three times during the summer from the open hose
mb. The non-irrigated plot made superior growth, the plants
g greater height, and spreading better. The reason for this is
y not in any dislike of the plant for water, but because of com-
the heavy clay soil by surface watering. The conclusion seems
ed from our own experience, and from the testimony given below,
fairly loamy soils in regions of moderate rainfall, at least, Texas
ss may be expected to speedily secure a good hold on the ground,
ist summer drought remarkably well. Experiments now in
may win for it a wider commendation. The following extracts
rrespondence are important:

elton, Bangor, Butte County.—Texas blue grass failed. It seems to be killed out
rd soil.

. Phelps, Blocksburg, Humboldt County.—The same objection to Texas blue grass
rge stock ranges, arises as with the brome grass; it must be cultivated at first
uld a corn field. It grows well in winter, and when well started is valuable.

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C. W. Mallory, Smith's Ranch, Sonoma County.—I have tried Texas blue grass u land as dry as can be found in this county, and it has made a good growth, nearly two this season, where the native grasses have not made twelve inches growth. It k green and growing throughout the season.

B. B. Hogaboom, Franklin, Sacramento County.—Texas blue grass is as hardy a plan I have ever seen. It thrived on the driest land we have, growing slowly, but conti ously all summer, and starting strongly during the winter following.

C. W. Hatcher, Yolo, Yolo County.—Texas blue grass grew and spread all summer on clay loam—about seven or eight feet to water. It resists drought well.

Robert Hastie, Clayton, Contra Costa County.—Texas blue grass sent up seed stems, died before perfecting seed, owing, apparently, to lack of moisture.

Austin J. Roberts, San Leandro, Alameda County.—I have been testing Texas blue g for two or three years, and I find it well adapted to the climate of California, stanc our warm, dry summers without dying out, and springing up into vigorous growt soon as the rainy season commences. It has been grown by me successfully, even gravelly soils, without a drop of water from May until October, yielding a crop of hay ensuing summer, at the rate of two tons and a half to the acre. Planted on good and occasionally irrigated during the summer, its growth is luxuriant, affording m cuttings and producing an enormous yield of feed. It is highly relished by stock, ei in its green state or made into hay. I have chiefly propagated it from roots, as, from woolly nature of the seed, it is very troublesome and difficult to sow. I obtained sev thousand root-sets from Alabama three years ago, and planted them in rows eigh inches to two feet apart, and twelve inches between the plants. They soon spread came together, forming a matted turf. I find this grass stands the cold weather of winters very well, unaffected in its vivid green color by a temperature of even on two degrees below freezing. For lawns it would require far less water than the K tucky blue grass, the grass usually cultivated for this purpose. The strong, rapid, orous growth of the Texas blue grass under the stimulus of frequent waterings m be an objection.

Henry Murphy, Milo, Tulare County.—The Texas blue grass roots were potted and cared for, but they failed to grow.

James Nash, Stuart, Santa Barbara County.—Texas blue grass roots died soon a being planted. We had five nights of very cold weather.

Al. Fielding, Santiam, Linn County, Oregon.—Roots of Texas blue grass, planted February, died out.

SCHRADER'S BROME GRASS—BROMUS UNIOLOIDES.*

A full account of the introduction of this grass to this State, and general history, were given in our report for 1885–6. It was also th shown to have special adaptations for California conditions. Our la experience with it, and the full reports which we have recently recei from correspondents in nearly all parts of the State, entitle it to ra as one of the best grasses ever introduced. It does not, however, poss the ideal qualities for which California stockmen have been long looki for there are situations too dry for it, and it is to a certain ext dependent upon volunteer seeding for its permanence. Still, it resi drought wonderfully, and, under moderately favorable conditions, roots live from year to year. This perennial tendency, together w its free-seeding habit, render it permanent and progressive in m places in which it has thus far been tried. Its wide range through the State and many of its special characteristics are well brought in the following extracts from correspondence:

Mrs. Ada Hall, Alturas, Modoc County.—The brome grass deserves special praise a forage plant. It stands drought and cold weather well.

Howard F. Webster, Crescent City, Del Norte County.—The brome grass was planted March, and came up in a short time, but made a poor, straggling growth the first seas It lived through the winter, but made a very poor growth this year.

K. S. Williams, Shingletown, Shasta County.—Schrader's brome grass, sown eight months ago on irrigated land, made some growth, and some bunches are still growing

J. H. Janssen, Redding, Shasta County.—Schrader's brome grass grew rather slowly about seven inches, after which the stock ate it off, along with the stubble.

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*Botanical synonyms are: *Bromus Schraderi, Ceratochloa Australis*, and *C. unioloi* other common names are: "Rescue Grass," "Iverson's Grass," and "California Pra Grass"—the latter being its chief title in Australia.

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Rawlee, Cassel, Shasta County.—Schrader's brome grass grew, and a few stalks
ds last year. This spring a few bunches were observed growing, but all seemed
want of water, although sown on ground which I had used as a vegetable garden
rrigation. I consider Schrader's brome grass of no value in this locality.
harr, Red Bluff, Tehama County.—Schrader's brome grass does well here without
vation. My land is of an adobe nature, but without the large cracks in sum-
ere is no peat in it.
. Snelling, Paskenta, Tehama County.—I sowed the Schrader's brome grass on
d on January 17th, and without irrigation it produced an abundant crop of feed
which all kinds of stock were very fond of. It remained green and continued
hough eaten off, until October. I saved a portion of the seed raised and sowed
ember and in January, and none of it came up, nor was it reproduced from the
here is none of it left. I do not know the cause.
Mullen, Big Bend, Butte County.—Schrader's brome grass grew well all the first
e season. Whether the dry weather or my pigs and chickens got away with it,
ot. Perhaps when the rain comes it may start again.
elton, Bangor, Butte County.—Schrader's brome grass grows well, and I think
great value in the lower foothill lands.
Iontoux, Williams, Colusa County.—Schrader's brome grass grows vigorously early
ing, the same as wild oats. It grows from four to five feet tall and makes good
or hay.
IcKaig, Little Stoney, Colusa County.—Schrader's brome grass does well here, so
l and climate are concerned, but I have been unable to obtain a stand on
f poultry and birds.
Bates, Brownsville, Yuba County.—Schrader's brome grass grows well, in some
een shoots to one stool, twenty-seven inches high, bearing heavy heads. It
is therefore not good for hay. I consider it a good pasture grass.
Foulke, Maple Creek, Humboldt County.—Schrader's brome grass was a success.
r seed, and cut it three times afterwards before the rainy season set in. The
ner seemed to have no effect on it.
beler, Englewood, Humboldt County.—Schrader's brome grass was sown in the first
pril. It came up well and grew fast. I have cut it for seed three times, and
all be able to cut it again. It comes along very quickly after cutting, and if it
ly well in winter, it will excel every other forage plant that I have ever tried,
excepted.
T. Harbert, Ferndale, Humboldt County.—After three years' trial I am pleased
rader's brome grass, and consider it quite equal to other good grasses like
rass and rye grass. From a patch of eight square rods, I cut a crop which I
in May; and in August I cut again, getting sixty pounds of seed. In October
it was from six to twelve inches high, nice and green. The cold spell which
ometimes during the winter does not hurt it at all, and in the dry season it is
he time.
. Phelps, Blocksburg, Humboldt County.—Schrader's brome grass has done well
e sufficient pains are taken in preparing the ground to give it a good start. It
ucceed sown upon the ground without cultivation.
eeves, Willits, Mendocino County.—Schrader's brome grass made a fine growth.
about the same time as grain hay. This is a fine grass, and will do well on any
will produce an ordinary crop of grain hay. In my opinion, it will yield about
ay per acre, on average land, as grain hay.
Gaine, Point Arena, Mendocino County.—Schrader's brome grass is doing well,
k will make a good forage grass for this section.
heney, Smith's Ranch, Sonoma County.—Schrader's brome grass grows well the
but like the mesquite grass (*Holcus lanatus*) dies out soon; not suited for a
t pasture.
Edwards, Penn's Grove, Sonoma County.—Schrader's brome grass was doing very
in my absence was plowed under by mistake.
der Naillen, San Francisco.—Schrader's brome grass, planted very late (on hill
apa County), had only one good rain, and did remarkably well—better than
grass. It is green and juicy as late as September.
wen, Zem Zem, Napa County.—Schrader's brome grass will be a valuable addition
tures, though it seems to require moderately rich and moist soil, and is almost
n high, gravelly points.
Cosby, Sacramento.—Schrader's brome grass came up and grew nicely, consider-
xceptionally dry season and lateness of sowing. Judging by my very limited
e, I think it valuable as a forage plant.
ogaboom, Franklin, Sacramento County.—Schrader's brome grass is a very good
arting early and producing an abundance of seeds. It is not affected by frost.
y well on unirrigated ground. I think it will be a good summer feed, as it grows
year, and cattle are very fond of it.
Iaslin, Pino, Placer County.—Schrader's brome grass flourished on unirrigated
nd, and I shall try to extend its culture.
urner, Valley Springs, Calaveras County.—With no irrigation Schrader's brome
awhile on red foothill soil, and then gave up to the unusually dry season.
regory, Jenny Lind, Calaveras County.—Schrader's brome grass grew finely and
a large quantity of seed which, with the parent stocks, covered the ground with

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a dense mat of turf after the fall rains. It seems a valuable acquisition. I grew it bottom land badly covered with sand from mining debris.

Fred. Greve, West Point, Calaveras County.—Schrader's brome grass I do not think m of. We have another species of brome grass growing wild here, which resembles Sch der's. Cattle will eat it when young, but after awhile they will not touch it, and would rather not have it on our land.

F. Femmons, Gertrude, Fresno County.—Brome grass grew well and seeded heav almost like oats. In the fall I noticed that stock ate it in preference to alfalfa, wh grew alongside. In the winter the brome grass came out fresh and green, and I fin scattered in many unexpected places. I am hoping to find it a *valuable* addition to forage grasses.

A. M. Acton, Gertrude, Fresno County.—Schrader's was planted in a gravelly soil, v poor. It grew very well, although probably not so strong as it might have done i it been planted earlier in the season. I secured a limited quantity of seed, sufficient another trial.

E. R. Pierson, Raymond, Fresno County.—Schrader's brome grass made an excell growth on dry, sandy loam, and appeared perfectly at home, while Hungarian bro grass dried up. I believe the former will be an excellent grass for this section.

L. A. Winchell, Fresno City.—The brome grass which I received from the Univers two years ago, is certainly a remarkable grower, and prolific beyond any expectati It is a very desirable grass.

Henry Murphy, Cramer, Tulare County.—Schrader's brome grass seed came up well made a growth of twenty inches. It resisted drought well and was green all sumn but the frost killed it. I divided my seed with a friend, who had like experience. It not do in our locality.

Mrs. Philena A. Murphy, Cramer, Tulare County.—Schrader's brome grass was sown A 5th. It made a slow growth, and was killed by frost.

E. D. Wheatley, Delano, Kern County.—The brome grass grew quite well, but it was properly protected from the rabbits, and I think it is all dead. It was on alkali soil.

C. W. Meade, Pescadero, San Mateo County.—Schrader's brome grass, sown on hill black loam, germinated scantily, but made a fine growth of about four feet. It is rat more leafy than Hungarian brome. It died down somewhat in the fall. The next y it increased, but since then the native grasses seem to be crowding it out.

F. Spangenberg, Cupertino, Santa Clara County.—The brome grass is valuable if st can be kept off it until well established. It has kept green with me all the year. this neighborhood I would prefer alfalfa on the hills, as more abundant in amoun foliage, etc., particularly as alfalfa after two years is hard to pull up, while brome g is just the reverse.

F. U. Eggleston, Watsonville, Santa Cruz County.—Schrader's brome grass came up right. I think it is of too slow growth for this section.

Isaac Dakin, Soquel, Santa Cruz County.—The brome grasses have been eaten off fall, but are green, and will probably start with the rains. I think they will pr valuable.

John Wandell, Hollister, San Benito County.—I planted Schrader's brome grass in a two hundred feet long. After it came up I watered it. It stooled out two feet wide made a rank growth. When about four feet high I cut it off six inches above ground and fed it to cows, horses, sheep, and poultry. All liked it. It afterwards g five feet high and went to seed. I gathered about ten quarts of the seed. I think valuable forage plant, especially where it can be irrigated.

Linwood Palmer, Arroyo Grande, San Luis Obispo County.—The brome grass is a g forage plant.

H. M. Maxwell, San Miguel, San Luis Obispo County.—Schrader's brome grass did mature seed or thrive in any respect under the same conditions with wheat and bu grass, which yielded well.

James Dearden, Paso Robles, San Luis Obispo County.—Schrader's brome grass does here, but the gophers seem very fond of it.

H. Brundage, Montecito, Santa Barbara County.—Schrader's brome grass is rather uns isfactory.

F. S. Gould, Santa Barbara County.—Schrader's brome grass, sown in rather stiff soi February, bore seed-heads in May. The Hungarian had in the same time grown but inches and seemed less vigorous.

W. H. Frink, El Casco, San Bernardino County.—Schrader's brome grass, sown in Ma on dry, sandy loam, grew fifteen inches high, and remained green until the middle of J

George Wright, Temescal, San Bernardino County.—Last year Schrader's brome g seemed a failure, but this year it has come up out of the old neglected roots with a thr growth, and I think that on our very dry gravelly soil, with our hot and dry climate, produce as much as timothy does in the East.

H. H. Gird, Fallbrook, San Diego County.—Schrader's brome grass proved excellent dry feed, and came on quickly after the first rain, like the California annuals. One y however, an early fall rain brought it up, and it perished during a long dry spell foll ing. There seemed no seed left in reserve, as is the case with our annual growths.

Mrs. L. S. Cleland, Mesa Grande, San Diego County.—You cannot recommend too hig Schrader's brome grass for southern pastures. I know of no grass for which I wo exchange it. It is now green (September), when all the native grasses are dry and bro After several years' trial it has stood all tests, and I consider it the most valuable gra know of for this section.

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Hoffman, Helix, San Diego County.—Schrader's brome grass is doing nicely, does not spread as rapidly as I expected. I gave it no irrigation, but it has cultivated.

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pafford, Hardin, Crook County, Oregon.—The brome grass did first rate.
in Dolbear, Wenas, Yakima County, Washington.—Schrader's brome grass was sown upon ground which could not be irrigated. It grew well until the frosts of , bearing a great quantity of seed. The cold winter entirely destroyed the roots, lso the roots of the Johnson grass. For this reason I think it useless to try the n of these grasses here.
Villey, Oakland, Mason County, Washington.—The brome grass was planted on lly soil. It made only a small growth, but is still green (September). It is pro- me seed, but would do better on better soil.

HUNGARIAN OR AWNLESS BROME GRASS—BROMUS INERMIS.

grass was introduced by this station from Europe about ten years l was first offered for distribution in this State in University No. 22, issued November 15, 1884. This statement is made in the fact that it has been reintroduced as a promising novelty ern experimenters during the last two or three years.
drought-resisting character of the grass was early seen in our ental plots in Berkeley; and, grown alongside of Schrader's rass, has surpassed it in satisfactory growth, being softer and afy, and bearing seed which clings more tenaciously to the stems, re finer than those of Schrader's brome. Under the conditions ng in the central coast region of the State, it may be commended y to please the grower better than Schrader's. It does not, , prove so hardy, and cannot be commended so widely, as the g reports clearly show:

avidson, Montague, Siskiyou County.—I am well pleased with the growth of ass. The unprecedented drought of this spring prevented it from coming up that which did come up grew finely to the height of about two and a half feet, ined a wonderful amount of forage leaves. Each plant is now (after our first ding out shoots in every direction, and will, by spring, form a complete sod. sider a very important item, as it would thus in a very short time form a sod oor set is obtained by sowing. I think it a very valuable grass for this section.
olland, Shasta.—Hungarian brome grass, tried by my neighbors and myself, has well, although sown on several different soils and situations.
ton, Leighton, Shasta County.—Hungarian brome grass, sown April 20th, grew ee inches high and dried up.
iser, Shasta City.—The brome grass is doing well.
Sawyer, Table Bluff, Humboldt County.—The Hungarian brome grass grew well soil. The blades grew eight inches high and the seed stalks about two feet. It reen all the season.
ubeler, Englewood, Humboldt County.—The Hungarian brome has made a fairly th. I have cut it once. It is still green (September 20th).
Dickinson, Yager, Humboldt County.—Hungarian grass kept green all summer, ot make much crop. It has been the worst grass season I have seen here in the ng sixteen years' residence.
oalson, Christine, Mendocino County.—The Hungarian brome grass seed came up is doing well, considering that we had no rain in March or April, and a very ver in May. In June it rained enough to wet the top of the soil. I think that will do well here when it gets set, but that has to be tried yet.
Gaine, Point Arena, Mendocino County.—The Hungarian brome grass is doing I think will make a good forage plant for this section.
phen Kempster, Cuffey's Cove, Mendocino County.—The Hungarian brome grass nd grew very slowly, but not to any height. I think it will do better after the It was planted in loose sandy soil.
ddington, M.D., Bartlett Springs, Lake County.—Hungarian brome grass is a orage plant; all kinds of stock *love* it.
der Naillen, San Francisco.—I sowed the Hungarian brome grass very late (in nty) on hill land, and the seed had only one good rain. It did remarkably n Bermuda grass, being to-day (September ?) green and juicy.
McKaig, Little Stony, Colusa County.—The Hungarian brome does well here, as and climate are concerned; rather better than Schrader's brome grass.

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E. W. Maslin, Pino, Placer County.—Hungarian brome grass flourished on unirriga granitic land, and I shall try to extend its culture.

H. W. Turner, Valley Springs, Calaveras County.—The Hungarian brome grass was so in red foothill soil. With no irrigation it came up and grew well, but it did not st the unusually dry season.

Raymond Plasse, Jackson, Amador County.—The Hungarian brome grass grew, but not stand the summer drought of our foothills.

M. F. Gregory, Jenny Lind, Calaveras County.—Hungarian brome grass grew well, did not ripen seed. The growth started well after the fall rains, but the plant does seem to have the vitality of Schrader's brome.

C. W. Meade, Pescadero, San Mateo County.—Hungarian grass sown on black loam h side, northern exposure. Grew three feet high and over; remained green all sum and fall, and started into a quick, strong growth after the first rains, seeming to g ground against other grasses.

F. U. Eggleston, Watsonville, Santa Cruz County.—The Hungarian brome grass came all right. I think it is of too slow growth for this section.

Isaac Dakin, Laurel Glen Fruit Farm, Santa Cruz County.—The brome grasses have b eaten off this fall, but are green, and will probably start with the rains. I think t will prove valuable.

A. M. Acton, Gertrude, Fresno County.—Sowing of the Hungarian brome grass seed delayed until March 14th, and no rain fell after that date. The grass grew, but did bear seed. It was planted in soil composed principally of decomposed oak leaves, somewhat shaded. I notice since the fall rains that it is showing up nicely from old root.

E. R. Pierson, Raymond, Fresno County.—Hungarian brome grass started well, but d up before going to seed.

Wm. Walker, Olancha, Inyo County.—The brome grass has done well. It seems to peculiarly adapted to this climate and soil. Our soil is sandy and slightly alkali.

Wm. Lockstone, Jamul, San Diego County.—I don't think much of the Hungarian br grass.

P. B. Litton, Elsinore, San Diego County.—Hungarian brome grass did not live thro the summer on sandy loam upland.

TALL OAT GRASS—ARRHENATHERUM AVENACEUM.

This grass did so well in our experimental plots at Berkeley fo number of years, that we have placed the seed in the hands of a nu ber of local experimenters in different parts of the State. The gr starts quickly after the fall rains, and makes an excellent win growth. In loose soils, to which it is best adapted, it roots deeply a holds its verdure late in the summer, but it is more sensitive to drou than the brome grasses previously considered. It is, however, kept summer growth with moderate irrigation, and even without water roots will, in most regions, survive the dry season. It is chiefly, h ever, as a winter grass that it is likely to prove valuable on this co as it does in the Southern States. Data now available indicates fitness of the grass for Northern California and the upper States of coast. It is desirable that experiments be made with sowing of tall grass with alfalfa to improve winter pasturage. It is known to succ when sown with red and white clovers in regions where those clo succeed. It is also desirable to try it as a mixture with orchard gr which is one of the best grasses for the coast region (at least) California.

The following testimony is furnished by growers of tall oat grass:

George Bates, Brownsville, Yuba County.—Tall oat grass is something wonderful. I cou in September eighty-two shoots from one stool, all from one seed, planted the last of preceding April. It is a good grass for hay or pasture, and promises to cover the gro very rapidly. If seed were sown eight inches apart it would cover the ground the year. At the same distance orchard grass would take three years to cover the grou and timothy would never do it.

E. C. Coburn, Middletown, Lake County.—Tall oat grass, planted on well-manured, l soil, made a fair growth and withstood drought tolerably. Most of it sent up shoots the fall rains and made a good growth. The grass sown on dry pasture was destroye rabbits.

Robert Hastie, Clayton, Contra Costa County.—Tall oat grass, sown on plowed grou

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owth of about thirty inches, with some seed stems over five feet high. It makes
The birds are very fond of the seed, and stripped the stems, but did not take
f other grasses I am experimenting with.

Overacker, Centerville, Alameda County.—Tall oat grass came up quickly and
until about two feet high. It ripened in August and was cut for seed. Sprouts
ely came from the roots without irrigation, and volunteers appeared after the
It seems a very valuable grass. It was grown on hilly land back of Mission

Gregory, Jenny Lind, Calaveras County.—Tall oat grass came up well, but suc-
o the heat, except a few plants which were in good growth in December follow-

ierson, Raymond, Fresno County.—Tall oat grass grew well on dry, sandy loam,
as thrifty as Schrader's brome grass.

ding, Santiam, Linn County, Oregon.—Tall oat grass was sown on good wheat
ll exposure to the sun. It grew about four feet high, and seeded well during
ally hot and dry summer, and started immediately after the rains. I think it
t grass for pasture in this region. It was the favorite of all who examined my
ntal plots.

MANY-FLOWERED MILLET GRASS—MILIUM MULTIFLORUM.

ailed account of the introduction and early success of this grass
en in our report of 1885–6. For the last few years we have made
te distribution of the seed as there was call for it. Most growers
succeed in getting a stand of it. The seed is small and difficult
ination, and often does not appear until the second year. By
ie, no doubt, many experimenters forget the place of sowing and
heir care, so that the plant does not receive the protection it
and it is destroyed by stock before it can get a good hold on the
Whether the general failure reported by correspondents is attribu-
this cause, or whether the plant has, in fact, a very narrow
f adaptation, it is difficult to determine. The growth of the
rom year to year in our experimental plots is very satisfactory.
es a thick growth of blades and a very showy seed panicle, and
its verdure continuously. In addition to the data given in our
ort, we have the following:

Heintzen, Brown's Valley, Yuba County.—The many-flowered millet was sown on
13th on good loamy soil. I think it should have been sown in the fall, to get
benefit of the rainy season. It sprouted and grew slowly, but died on account
nt.

McKaig, Little Stoney, Colusa County.—I was never able to get a good stand of
ultiflorum, but the scattered plants grew luxuriantly, surviving the heat of
and the cold of winter, until last January, when it was all killed, apparently
cold.

Meade, Pescadero, San Mateo County.—The *Milium multiflorum* sown on black loam
rew three feet six inches high. It keeps green the year round.

nker, San Diego.—My place is thirty miles northeast of San Diego, at an eleva-
o thousand five hundred feet, with decomposed granite soil. The *Milium multi-*
s sown in March, but did not germinate until after the fall rains, and grew
high without irrigation. Horses and cattle eat it greedily, and it seems to me
we want in this part of the State.

Gird, Fallbrook, San Diego County.—The *Milium multiflorum* is a good grass. It
tself by seed on pasture lands, and shows green throughout the year. It starts
r at the first rain, often being a foot high at Christmas, and grows rapidly in
ther. In the absence of alfilerilla, and other feed of extra good quality, stock
l; they pull it up very badly if they are kept off when it is growing and put on
as attained height. It seems to stick better if stock are put on as soon as it is
I have stools of this grass five years old still vigorous, and showing green all
the year, on a high hill of granitic soil.

RYE FOR WINTER FEEDING.

growth of rye for winter feeding of dairy and other stock is quite
nt in the foothill regions of the State, and at points along the east

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side of the Great Valley. We have introduced and distributed a la collection of European varieties, which have been tried in compari with the common rye of the country. One of these, the St. John's D rye, has proved best adapted to local conditions, and was favora commented upon in our report for 1885–6. It makes a heavy grow in mid-winter, and it has full strength to maintain its heavy head most winter storms. The following testimony is corroborative of th earlier published:

Mrs. Annie Davis, Susanville, Lassen County.—We have had two years' experience w St. John's Day rye. Sown in the fall, it makes a splendid growth. We raise it on h land without irrigation. It makes fine hay, as it has so much foliage.

J. R. Boggs, Janesville, Lassen County.—This is a good rye country, as there are th sands of acres of good rich sagebrush land without water to irrigate, which will raise rye. The mistake usually made, however, is sowing too thinly to make good hay, and the ground is not protected from the sun's rays and wind, there is commonly obtai only a small yield of either grain or hay.

KAFFIR CORN AND MILLO MAIZE.

The old variety of *Sorghum vulgare*, known as *Dhoura*, and commo designated in this State as "Egyptian corn," has for many years prov of great value in this State, both when cut green, as summer feed stock, and when allowed to ripen its seed, which is widely used poultry, and, to some extent, as a substitute for barley as horse fe In the upper part of the Sacramento Valley Egyptian corn has b more widely grown than elsewhere, though it is more or less abundan grown all through the interior valleys. Near the coast, in the up part of the State, and to some extent along the coast generally, sum heat is too low to fully carry the plant to maturity, and it is usua adversely reported upon.

During recent years new varieties of *Sorghum vulgare* have b brought forward, and the seed has been distributed from this Stati Of these, two, known as "Kaffir corn" and "Millo maize," have prov most valuable, and are by many pronounced superior to the old varie They are characterized by a more leafy growth than the old "Egypti corn," and they bear their seed heads erect. They can be freely co mended as fodder plants, yielding several heavy cuts of forage ea season, if the ground is sufficiently moist, or, when allowed to ri seed in a region of adequate summer heat, they may be relied upon the main source of feed-grain in poultry farming. The following repo relate to the two varieties of sorghum already mentioned:

Fred. Scharr, Red Bluff, Tehama County.—Kaffir corn produced twice as much foli and weight as the Egyptian corn, and it was green all summer; besides, my stock to eat it much better.

E. A. Brinkerhoff, Forest Ranch, Butte County.—The Kaffir corn sustains its reputat for resisting drought. No rain fell from the middle of May until the last of Septem and not a stalk died from drought. With fairly good soil it is a grand crop both for s and fodder.

J. M. Addington, M.D., Bartlett Springs, Lake County.—Red Kaffir corn has done w growing seven feet high, with heads one foot. It sprouts readily after cutting. As fod however, stock prefer sweet corn.

Charles Lehn, Windsor, Sonoma County.—Kaffir corn, sown on good garden land M 29th, grew splendidly and reached a height of about four feet. It also started well a cutting for seed, but growth was stopped by heavy rains.

H. B. Carpenter, near Glen Ellen, Sonoma County.—Kaffir corn seems to do well h without irrigation.

C. W. Meade, Pescadero, San Mateo County.—Kaffir corn is in good condition to f when the first rains come, as it is not injured as fodder corn is, and the cattle are g enough to eat it then.

A. W. Edwards, Los Gatos, Santa Clara County.—I tried Kaffir corn this year and like

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lots of leaves, and is green and growing now (September), when all other corn pulled two weeks past.

s, Los Gatos, Santa Clara County.—Kaffir corn does not do very well here. It is ate toward both frost and drought.

Thompson, Corralitos, Santa Cruz County.—Kaffir corn has proved well suited for ntain district. It kept up a good, strong growth during the last very dry season.

Bowden, Bitterwater, San Benito County.—Kaffir corn, planted April 10th on poor, soil, was cut for cow feed about August 1st, and again later. The white variety ely; the red does not seed, but makes more feed, growing twenty-five to thirty the plant without irrigation.

man, San Ardo, Monterey County.—Kaffir corn makes good stock forage, but shows of seed.

yler, Bryson, Monterey County.—The white Kaffir corn makes a good growth and ought well.

Nash, Stuart, Santa Barbara County.—Kaffir corn grew well during the summer, nding out new shoots as late as November. I am satisfied it will be very valu- odder.

ndage, Montecito, Santa Barbara County.—Kaffir corn has done poorly, for which ign no reason, except it be lack of hot weather, owing to proximity to the coast.

Pimmick, Carpenteria, Santa Barbara County.—Kaffir corn (seed from Georgia) has arkably well; much better than Egyptian corn.

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harr, Red Bluff, Tehama County.—From the little packet of yellow millo maize and one half barley sacks of grain. The chickens like it as well as wheat, and like it as much as sugar cane, which also grows well here.

afferty, Wyandotte, Butte County.—The millo maize did well. It produced more other kind of corn that I have seen. I think it could be cut twice if it had water.

Hills, Marysville, Yuba County.—The yellow millo maize has made a finer growth ptian corn that was planted beside it. Stock eat it equally as well, but I am ared to say whether it is much superior to the Egyptian, taking all things into tion. Insects feed on it greedily.

Mason, Bridgeville, Humboldt County.—The yellow millo maize did not do much. his was caused by the long dry spell after it was planted. Then it was so wet er that it did not ripen. I planted it in an alder glade, and I think it may have wet a locality.

G. Smith, Healdsburg, Sonoma County.—The yellow millo maize is very prolific earing, surpassing the Kaffir and Egyptian corn, but the stalks are too woody s too small to amount to much for fodder if the seed is allowed to ripen.

Suhren, Suisun, Solano County.—The millo corn did not do well. Corn does not n my place.

ower, Yolo, Yolo County.—I planted the yellow millo maize on the first of April, ccount of the dryness of the spring, but little germinated, and the growth was attle eat the green fodder well, but did not care for it when cured.

Cosby, Sacramento.—The millo maize grew well, and matured large, well-filled

mith, Brentwood, Contra Costa County.—I planted the yellow millo maize on loose ur heavy winds killed three fourths of it when it was small. The rest of it is e and growing. I have gathered one twenty-two by thirty-six-inch wheat f the ripe seed heads, and I think there will be as much more, besides the fod- hink it will be valuable on my dry sandy lands. This has been an usually dry re.

. Sanders, Gilroy, Santa Clara County.—We planted the yellow millo maize in our ut it was late. It looks pretty well. Some of the stalks measure five feet four alf inches high, and it has not tasseled out yet (September). The soil is adobe

bel Luke, Soledad, Monterey County.—The yellow millo maize did well. In yield- ar ahead of any species of corn that I have planted up here.

k Albright, Estrella, San Luis Obispo County.—My yellow millo maize is doing orly, but I shall get seed enough to give it a further trial. My cow won't offer fodder.

Pimmick, Carpenteria, Santa Barbara County.—Yellow millo maize has done re- well, much better than white millo maize. It can be cut here about three the season. It is very valuable on land a little too dry for alfalfa, and it makes ter flavored butter than alfalfa.

ockstone, Jamul, San Diego County.—The yellow millo maize matures in good

HNSON GRASS, OR EVERGREEN MILLET—SORGHUM HALEPENSE.

plant was widely distributed throughout the State about ten go, both by dealers and public institutions. Our report for 1885–6 s quite an extended review of the plant, and a large number of

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reports from those who have grown it experimentally. Opinions are variance as to its value, except that all who have experienced its intrusi upon cultivated ground denounce it as an unmitigated pest and a grie ous burden, because efforts at its eradication are difficult and expensiv It cannot be denied that, on the whole, the State would be much bett off if it had never been introduced. It is so susceptible to frost, and sure to die out in dry waste places where its presence might be desirabl that its worthlessness as a dry-land plant must be conceded. It is tenacious and difficult to root out on lands kept moist by cultivation, on those naturally sub-irrigated by seepage water from natural or ar ficial watercourses, and so prone to spread on irrigated lands by carria of seed in irrigation water, or by distribution of the roots by plow cultivator, that it is denounced in unmeasured terms by those seeki to use such lands for orchard, vineyard, or field crops.

Very expensive work has been undertaken in the eradication Johnson grass. Some have extirpated it by actually digging ou hauling away, and burning every particle of root which could be fou from surface to hardpan, and afterwards watching for and repressing at each subsequent outcropping. It is doubtful if such heroic tre ment is necessary, providing one will undertake systematically a unremittingly a surface treatment. If the roots are thrown up to s and air at the time of the year when the soil and air are driest and t heat most intense, the furrows being left standing on edge as much possible, the roots can be gathered by harrowing after drying out, a burned. After disposing in this way of as many as possible, the aft growth can be repressed by working the ground over about once a we with a cultivator with flat, sharp teeth; this should be done at stat intervals, whether the grass makes much show above the surface or n In fact, the success of the method depends upon never allowing t plant a glimpse at the light. If it be allowed to make a top grow before using the cultivator, then each cultivation will but enable it more quickly recover the ground by distributing its roots, but cutti it continually below the surface will finally exhaust and kill out t roots. This is the method which gives best results in the extirpati of the wild morning-glory, and no aerial plant can withstand su treatment. It must, however, be pursued for a period long enough accomplish the results, and not taken up spasmodically or stopped t soon. On drier, heavier soils the plant can in many cases, no dou be killed out by very little treatment after the dry plowing first me tioned.

As to the value of Johnson grass as stock feed there is some differen of opinion, arising, to some extent at least, from the stage of growth which different growers have used it. It is undoubtedly acceptable animals when the growth is young and succulent. It is also readi eaten when growing with alfalfa, and it is believed to obviate blo which is common among animals turned into alfalfa fields.

The following extracts from our correspondence relative to Johns grass is supplementary to that published in our report of 1885–6, which allusion is made above:

Wm. H. Mullen, Big Bend, Butte County.—The evergreen millet roots never amoun to much. It is living yet, but not growing or spreading as it should. It is in a very d place.

Eugene Melvin, Paradise, Butte County.—The *Sorghum halepense* roots, even in shall soil, were unhurt by the cold of winter. It keeps green all summer on dry, shallow s

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pastured or cut; otherwise it goes to seed, and dries up in the fall, but comes
om the root in the spring. I find some difficulty in getting it to grow from the
he seed comes up so late in the spring that the plants are not strong enough to
e first summer heat. It has never failed to grow with me when the roots were
I have broken them three or four joints in a piece, scattered them on the ground,
plowed them under, with very satisfactory results. I have never seen horse or cow
eat it. The pigs eat both roots and leaves, and the chickens eat the seed. I am
ased with it as a summer forage plant for dry, shallow soil. I have not tried
for hay.

Hodge, Hanson, Humboldt County.—The evergreen millet all died.

Reeves, Willits, Mendocino County.—Evergreen millet is a late grass, with rather
af and stalk. It bears a large amount of fine seed. Sown in April the seed is
ipe (September). On grain hay land I think it would yield a heavy crop of hay
green summer pasture.

Marsh, Glenbrook, Lake County.—I have tried evergreen millet, but it will not
e cold.

Reynolds, Kelseyville, Lake County.—The evergreen millet lives and grows well
water on our high upland, but it is not desirable for my purpose, for the reason
so easily killed by frost, and stock are not fond of it.

Chrisman, Lower Lake, Lake County.—I planted roots of the evergreen millet
ent soils. All that was planted on cultivated land grew and is growing yet,
tanding I have plowed the ground two or three times since, which only caused
e up thicker. It seems to be excellent food for all kinds of domestic animals.
asily bitten down by frost as corn, though it will grow right up again in the
I also sowed some of the seed on a very dry sidehill, which also grew all summer;
and was unprotected from rabbits, and they dug it out and destroyed it.

. Hilton, Glen Ellen, Sonoma County.—The evergreen millet roots were planted on
e, eastern exposure, on adobe soil. They soon died out.

Edwards, Los Gatos, Santa Clara County.—Would note among valuable forage
ne evergreen millet as remarkably thrifty in loose soil, and when once rooted it
rd to get out. It is eaten readily by stock.

Guss, Wrights, Santa Clara County.—I find it almost impossible to kill out the
n millet, and think it might make fair pasture after cattle get used to it.

Babb, hills east of San José, Santa Clara County.—Evergreen millet is a troublesome
orchard or cultivated land, but disappears in uncultivated pastures.

mith, Diamond Springs, El Dorado County.—We sowed the "Johnson grass" in a
bottom with clover, and it has done very well. The horses are very fond of it,
a strong wiry plant.

Murphy, Cramer, Tulare County.—For two years I have grown the evergreen mil-
mall scale. I like it; it does well with me. Stock of all kinds like it. Horses,
ogs, and chickens relish it. It will make two crops a year, and furnish plenty of
nogs during winter.

lthearn, Alpine, San Diego County.—Sorghum halepense is a failure in this vicinity.
es not kill it, but it does not yield enough and is too coarse and woody.

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abbitt, El Paso, Texas.—Johnson grass is splendid for cows; makes sweet milk
er, and makes good hay. It is easily and cheaply started, and stands the
better, and yields a greater amount of feed per acre than alfalfa. and the milk of
on it lacks the clover taste which alfalfa imparts. But it has one terrible draw-
e can't, as yet, control it; can't kill it out. The seed floats down the ditches;
ry it; a little bit of root on the point of the plow, all serve to give it a start in a
ce. And what promised to be of such value in this dry soil of the Rio Grande
where nothing grows without irrigation, seems to be about to master us. It may
f not irrigated, but it will not do so in one year.

ESPARCETTE, OR SAINFOIN—ONOBRYCHIS SATIVA.

clover has attracted much attention in this State during the last
ears, because of widely circulated reports of its success on dry
n the State of Nevada. We have grown it continuously in our
mental plots in Berkeley for the last twelve years, but have never
ason to form a very good opinion of it. Our soil in Berkeley is,
er, of an adobe type, and our climate cool from proximity to the
San Francisco. As the region from which its notable success
orted was one of light, dry soils and high summer heat, condi-
which have always been considered desirable for the growth of
n in European countries, we surmised that our unfavorable opin-
the plant was due to lack of adaptation in our conditions. To
ine this point, and to give our correspondents opportunity to test

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the plant which was so highly praised, we furnished seed to many ap cants during the winter of 1889. Their experience, which will be c lined below, indicates that the plant has been greatly overpraised perhaps that too wide application has been made of the experienc some growers who enjoyed exceptionally favorable conditions. Th are, however, indications in the reports that this clover may prove v satisfactory, locally, under suitable conditions. Records of experie covering longer periods are necessary to determine definitely the sta ing of the plant in California:

Peter Klink, Berryvale, Siskiyou County.—The forage plant called sainfoin, received years ago, is still growing, but it only attains a height of about nine inches here, a elevation of three thousand five hundred feet, at the foot of Mount Shasta. I think seasons are too short.

Thomas Dickinson, Yager, Humboldt County.—Esparcette was killed by the sum drought, the worst I have seen here in the hills for sixteen years.

George Bates, Brownsville, Yuba County.—Esparcette, sown in April on dry soil, l through the dry season, and seems to promise well. Where it was irrigated it did do as well as red clover.

C. W. Hatcher, Yolo, Yolo County.—The esparcette seed was sent to a friend in Ande Valley, Mendocino County, who writes that it came up well, grew remarkably well, produced an abundance of hay.

R. C. Marsh, Glenbrook, Lake County.—I tried sainfoin last spring (1888), but only a seeds grew, and they have all disappeared.

J. M. Addington, M.D., Bartlett Springs, Lake County.—Esparcette does nothing wit as expected. With irrigation it only attained a height of fourteen inches, while al was three feet. The alfalfa was cut three times, while the esparcette, after the first ting, grew but eight inches, when frost came and stock was turned upon it.

Frank Owen, Zem Zem, Napa County.—My experience with esparcette leads me to bel it inferior to alfalfa. It needs the same soil and climate to perfect it, and it will thrive upon dry hill pastures.

Thomas J. Pilkington, Trenton, Sonoma County.—Esparcette sown in the spring in nection with orchard grass on a bush-burn in the ashes, did not grow, but the orcl grass made an extremely good stand.

John Marshall, Sebastopol, Sonoma County.—Esparcette was sown on good ground in order and well harrowed in. About one fourth of the seed came up, and grew during summer to be about two inches high and the same in breadth. I think it does not this region.

E. H. Cheney, Smith's Ranch, Sonoma County.—I have tried esparcette clover on land where the bedrock came within one foot of the surface. The seed was sow March. It has made about eight inches growth, and is, at this writing (September 1 growing, and is as green as grass in the spring. If it is a good forage plant, and stand such a severe test as I have given it, it will be valuable.

J. M. Benson, Elliott, San Joaquin County.—Esparcette did very well at first, but I do think my land is adapted to it, as it is inclined to bake and crust.

John H. Eden, Nevada City, Nevada County.—Esparcette and alfalfa, in adjoining patc were covered with hail, in May, which stood on the ground about thirty-six hours, killed both plants.

C. W. Meade, Pescadero, San Mateo County.—I made two sowings of esparcette—on January and one in May. That sowed in January grew a little over two feet high, bore seed twice—once in August and again in October. It was sown on a loose, black that was covered with hazel brush two years before. The sowing in May was mad black loam, near the cow corral, very rich and very foul. It was sown in drills, and hoed once. Few of the plants bore seed, but it made a big root growth. The roots were from one foot to over two feet in length.

M. Gorman, San Ardo, Monterey County.—I got a pretty good stand with esparcette high, dry hillside about three hundred feet above the level land. Some stalks grew a nine inches high, bloomed, and ripened some seed. It appears to be good for dry sides where nothing else will grow.

J. B. Sayler, Bryson, Monterey County.—Esparcette has not done well with me, tho sown on good land.

R. S. Potter, Arroyo Grande, San Luis Obispo County.—We got but one plant from a l sowing on loose, sandy soil, but it made a medium growth and remained green all sum

George Weiss, Creston, San Luis Obispo County.—Esparcette, sown on black sandy l in April, kept green until September, and then started again after the fall rains. H have concluded, after four years' experience, that esparcette is not a success with me perennial forage plant. It grows well the first year as long as the ground is loose, when the soil is hardened by heavy winter rains the plants gradually die out.

E. R. Pierson, Raymond, Fresno County.—Esparcette made a good growth on dry sa loam, and went to seed, but contrary to my expectations the roots died.

E. S. B. Dunbar, Goshen, Tulare County.—Esparcette grew to a height of eight inc

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asshoppers came on and ate the leaves and stalks, and started in on the "button," ppears at the surface of the ground. This killed the plants.

Nash, Stuart, Santa Barbara County.—I planted esparcette in eight places. It only in one spot, and then died.

Harris, Santa Paula, Ventura County.—I and my neighbors have tried esparcette, t on well-prepared gravelly land, where trees and vines do well. It did not all , and that which did come up amounted to nothing.

Buehren, Acton, Los Angeles County.—Three neighbors and myself tried esparcette s in succession without success—but few seeds germinating. Our land is very l dry.

Litton, Elsinore, San Diego County.—Esparcette, on sandy loam upland, promised eventually thinned down to a few plants, which I hope to preserve, as I am in- believe it may prove valuable in this locality.

S. Cleland, Mesa Grande, San Diego County.—Esparcette grew well on a loamy until burned up by the unprecedented hot spell of July.

Irwin, Nuevo, San Diego County.—The esparcette grew well from the seed, and is beautiful clover I ever saw. Chickens eat it down to the very root.

Elding, Santiam, Linn County, Oregon.—Esparcette sown in February grew feebly, died out during the summer, but the plants which survived revived after the . I believe early sowing is necessary to get a good summer's growth.

SNAIL CLOVER—MEDICAGO TURBINATA.

plant is a native of southwestern Spain, and in its introduction stribution we have hoped to secure for the State another plant as le as its botanical relative "burr clover" (*Medicago denticulata*). ail clover has a smooth pod, which cannot attach itself to the sheep or hair of goats as does the toothed burr of burr clover. od is more than twice the diameter of the latter. The growth of ail clover resembles that of burr clover, but with us it is much . It starts from the seed as soon as the earth is moistened by rains, and makes a strong growth during the winter and spring, up as soon as its vast crop of seed pods ripens early in the r. It volunteers freely from these seeds, and thus repeats itself ear to year. The letters below show that some experimenters robably been misled by this summer disappearance of the plant, conclusion that it does not succeed. Others doubt its self-main- e when grazed. This point must be determined by longer ation. We question whether it will prove less tenacious than lover, although the larger pod renders it more readily gathered. tearing open the pod and sowing the clean seed, as one corre- nt recommends, we have never seen occasion for that. It seeds with us without even covering the pod with earth, and we presume do the same wherever burr clover will do it.

following reports cover nearly the whole State, and the preponder- the evidence is strongly in favor of the plant. It is evident that wth will be freest and most satisfactory where moisture is abundant, at in exceptionally dry and hot situations its growth may be and the plant of little account. It also shows liability to frost- in some localities; we think, however, that the following testimony its its trial by those who have not yet had opportunity:

Foulke, Maple Creek, Humboldt County.—The snail clover did well, although it in starting.

Habeler, Englewood, Humboldt County.—The snail clover came up and made a fine, owth, but the seeds are so large I fear stock will eat them entirely up so that it er seed itself. It soon died down on this soil.

Sawyer, Table Bluff, Humboldt County.—About one half of the snail clover seed t made a very rank growth, and produced about a half bushel of seed. Cattle ry seed stalks well. I do not know how the ground can be seeded with it. For ture it would not be practicable to pick the seed by hand.

Mason, Bridgeville, Humboldt County.—I planted the snail clover seed on a dry

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knoll and took no care of it after planting. I gathered a half gallon of seed. I think will do well here, if it does not need to be sown every year. It all died out.

Leslie Hoag, Boonville, Mendocino County.—The snail clover grew rank in the garden s produced a large amount of seed-balls. I will try it on a range next season.

W. R. Gaine, Point Arena, Mendocino County.—The snail clover does not do well he the climate is too cold, I think. It was planted on a high, dry, sandy loam, and it ca up all right, but the plants were puny and small.

Mrs. Stephen Kempster, Cuffey's Cove, Mendocino County.—The snail clover grew v well. I think it is more suitable for low wet places than for hilly land. It was plan in a loose sandy soil with plenty of water.

A. Requa, Cahto, Mendocino County.—The snail clover grew high enough to mow, s will prove valuable for this part of the country. I saved a couple of gallons of burrs.

E. L. Reeves, Willits, Mendocino County.—The snail clover did not come up very thi but that which did come up made a fine growth. It bears a large amount of seed s ripens pretty early. I think it would make good pasture, but would not do for hay, it lies close to the ground.

J. H. Adams, Occidental, Sonoma County.—Snail clover, planted May 10th in ri sandy soil, made a growth of about fifteen inches, kept green quite late, and was v full of seed burrs, which were very large. I think this will be a fine feed.

A. Van der Naillen, San Francisco.—The snail clover was planted on hill land in N County and received only one good rain. It was almost a failure, still the five or plants gave a great many burrs or snails.

Fred. Scharr, Red Bluff, Tehama County.—Snail clover does here as you say it does Berkeley.

C. F. Shelton, Bangor, Butte County.—Snail clover is killed out on dry, baked soil.

Eugene Melvin, Paradise, Butte County.—A little of the snail clover matured seed, the plants grew only a few inches high. It was planted in February in good soil.

Benj. Sanford, Smartsville, Yuba County.—The snail clover this summer does not s pass our burr clover.

Geo. Heintzen, Brown's Valley, Yuba County.—I sowed the snail clover on February 1 on good loam soil. It came up nicely and grew, but was stunted by the dry seas It was about eight inches high when it succumbed to the drought. I think it is supe to our burr clover, as the seeds are smooth. I should like to have tried it in the fall.

R. S. Alderman, Smartsville, Yuba County.—The snail clover was sown near the irri ing ditch, and grew somewhat thriftily, but did not prove equal to the burr clover, wh is at home hereabouts.

Joseph Clark, Anthony House, Nevada County.—The snail clover was taken by the bi as fast as it came up, with the exception of five or six plants, which matured. I th it will be of no value in this vicinity.

J. W. DeLameter, Newcastle, Placer County.—Snail clover grows, but not well, with irrigation. It grows well in winter, and makes a good growth of about one or two f

M. F. Gregory, Jenny Lind, Calaveras County.—Snail clover did well on bottom l badly sanded from mining debris. It produced much seed, which volunteered fin making good feed in December.

Fred. Greve, West Point, Calaveras County.—The snail clover did well.

Raymond Plasse, Jackson, Amador County.—The snail clover grew nicely. I gathe about a half bushel of seed. I think it will be a good pasturage for our hills—a good for sheep and cattle.

E. W. Maslin, Pino, Placer County.—Snail clover produced moderately well on unirriga granitic land.

B. B. Hogaboom, Franklin, Sacramento County.—Snail clover promises to be very va able for feed where frost is not severe. It seems quite susceptible to frost.

A. B. Harrison, Danville, Contra Costa County.—The snail clover, planted in my nurs grew well and produced considerable seed for future use. The plants have died dow

Oscar Smith, Brentwood, Contra Costa County.—The snail clover seed nearly all grew. plants were about one foot high and full of seeds, but they died early. I think it wil well here when we have more rain.

Howard Overacker, Centerville, Alameda County.—Snail clover sown on hilly land g rankly, and ripened seed in July. It looks like the common burr clover, except t the plant is three times larger, and has a large, smooth burr. It is better than comm burr clover, as cattle can pick up the seeds more easily.

L. L. Guss, Wrights, Santa Clara County.—The snail clover did not make nearly so ra growth as burr clover on the same soil.

Hyatt Hibbard, Paso Robles, San Luis Obispo County.—The snail clover planted Febru 27th, and kept well cultivated, ripened a fine crop of seed about June 20th.

Linwood Palmer, Arroyo Grande, San Luis Obispo County.—The snail clover yielded f one *single seed* (not a burr) two hundred and thirty burrs on cultivated ground. ground is heavy, clay and adobe, and the clover does not easily propagate itself. burrs should be torn open and the seed planted to insure growth.

E. S. B. Dunbar, Goshen, Tulare County.—Snail clover came up well and seeded freel

Wm. Walker, Olancha, Inyo County.—The snail clover was a complete failure. Perh I gave it too much water.

William Oliver, Bishop Creek, Inyo County.—The snail clover came up pretty well, in the spring. After reaching six inches in height, it did not grow any during the w weather; however, it spread well over the surface; but now (September) it has ma growth of four feet. I think it will flourish on this sandy land as well as alfalfa.

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L. Hall, Nordhoff, Ventura County.—Of the several forage plants received, snail one did well on the light, gravelly loam of a steep hillside, where I planted February. It produced double the seed sown, and will probably do much better r sowing.

itton, Elsinore, San Diego County.—Snail clover has done well on sandy loam oil.

Hird, Fallbrook, San Diego County.—Snail clover is too susceptible to frost to do ottom land.

udson, Escondido, San Diego County.—The *Medicago turbinata* did not do well.

ockstone, Jamul, San Diego County.—The snail clover did well, and has excited able interest.

BLACK MEDIC—MEDICAGO LUPULINA.

clover, which is also called "yellow trefoil," grew so well without on on our grounds, seeded itself so freely, and in fact appeared d there at a distance and grew so thriftily even in what seemed ost unfavorable situations, that we distributed the seed with the tion of disseminating a very valuable wild pasture plant. This in truth, to be its character in regions suited to its growth, but uirements are apparently rigid, and we can recommend it only er coast regions. The interior of the State and even valleys on t side of the Coast Range, south of San Francisco Bay, seem to dry and hot for it. Even in regions well adapted to its growth it ove most satisfactory on moist, retentive soils.

experience reported by the grower in Nevada is rather surprising, bably would be more intelligible with a better knowledge of local ons:

Melvin, Paradise, Butte County.—Some of the black medic seed was scattered he heavy rains in January, to compare it with the native grass, but none of it e up. Some, sowed in good soil in February, came up after a month's delay, and y slowly. It blossomed, but dried up in the hot weather of April.

Mason, Bridgeville, Humboldt County.—The black medic I planted on a dry piece d, and it has done remarkably well. It seemed to die out this fall, but since it has started up again and looks fine. It did not go to seed.

Babeler, Englewood, Humboldt County.—The black medic has made a slow growth. ot been able to cut it, but as it is still growing (September 20th), and should on after the early rains, I should think it a valuable plant, although I am t the present time to pass judgment on it.

Stephen Kempster, Cuffey's Cove, Mendocino County.—The black medic came up and t down. It was planted in loose sandy soil, well watered.

Ittington, Middletown, Lake County.—The medicago came up well, but has been so down by the rabbits that we cannot judge of its growth.

Bloom, Petaluma, Sonoma County.—The black medic grew finely.

Clark, Anthony House, Nevada County.—The black medic I tried in three different One patch I spaded up, another I planted where some brush had been burned, third was planted on a piece of rather poor land. Part of the seed I planted on 28th, and the rest I sowed two weeks after. The first and third pieces came up, destroyed by the insects. The second piece, where I burned the brush, came up eared to do well until the first of May. It then dried up and died, apparently ack of moisture.

Maslin, Pino, Placer County.—I have not succeeded in growing black medic on ted granitic soil, though I have tried it twice.

and Plasse, Jackson, Amador County.—The black medic did not grow at all. The on was very severe.

Turner, Valley Springs, Calaveras County.—The black medic was planted in red soil. With no irrigation it came up and grew well, but did not stand the unusu- season.

Greve, West Point, Calaveras County.—The black medic made a fair growth.

ick Albright, Estrella, San Luis Obispo County.—My main bed of black medic is cut ery roots by "jack rabbits," after putting a good many kinds of things on it to m off. It appears to grow pretty well. I have a few tufts of it in other places. it bloomed, but the heat and dry weather, with no spring rains, are against it

n Oliver, Bishop Creek, Inyo County.—The black medic came up late in the spring, not do well during the summer; but now (in September) it has made a growth of

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W. H. Frink, El Casco, San Bernardino County.—Black medic, sown in March on sandy loam, made but a scattering and weak growth.

M. E. Spafford, Hardin, Crook County, Oregon.—The black medic was sown on al ground. It never did any good.

Cyrus Smith, Wellington, Nevada.—Black medic, sown on dry upland, and irrigated the plants got a good start; grew afterwards for three months during the driest pa the season, with but one irrigation. It showed no signs of drought, but grew finely whole season. I think it the finest forage plant I ever saw, remarkably adapted to a climate. It has a flavor which seems to be acceptable to all domestic animals.

JAPAN CLOVER—LESPEDEZA STRIATA.

This plant seems to be a conspicuous failure under California co tions. It is exceedingly hard to get anything of a stand of it, an dwindles and disappears early in the summer, making no provis apparently, for its reappearance. Present information, after sev years' sowing on our grounds in Berkeley and reports from other C fornia situations, leads us to pronounce it worthless. If any Califo reader of this report should have found it otherwise, we would lik know it:

F. F. Barss, Placerville, El Dorado County.—I did not give the Japan clover, *as I th* a fair trial, as my farm had been cleared but a short time.

A. C. Davenport, Stockton.—The clover came up very scattering, and didn't do well.

Benjamin B. Hogaboom, Franklin, Sacramento County.—I do not think that the Ja clover will amount to anything on unirrigated land, as it is too dry for it.

F. Femmons, Gertrude, Fresno County—Japan clover grew well during the summer. the fall the stock did not touch it, having alfalfa and Schrader's brome grass in the s pasture. During the winter the cold weather killed the Japan clover.

Henry Murphy, Cramer, Tulare County.—The Japan clover failed to grow well. On few seed came up, and at this writing (September) looks sickly.

W. E. Willey, Oakland, Mason County, Washington.—The Japan clover was planted dry gravelly soil. It has made only a small growth, and has not blossomed yet (Sept ber), but it is still green. It would do better on better soil.

TANGIER PEA—LATHYRUS TINGITANUS.

This plant belongs to the "sweet pea" class, not to that of the c mon garden pea, and yet it yields a seed which, cooked as peas usu are, is very desirable for table use. It is the fact that the plant itsel liked by cattle that led us to distribute it. Such distribution was f made in 1889, and sufficient time has not elapsed for full data on subject; but at present we are very favorably impressed with its gro and possible value as a forage plant in some situations. As a nativ Barbary, it should be inured to heat and drought, and it has shown h its hardiness under low temperatures. An effort will be made to sec wider trial of it.

George Simmons, Yreka, Siskiyou County.—The tangier pea, sown in rows about t inches apart, is a very good forage plant, and yields abundantly.

C. W. Griffin, Newville, Colusa County.—The tangier pea is very productive.

J. M. Addington, M.D., Bartlett Springs, Lake County.—Tangier peas grew and bloo all summer and fall, and lived through two snow storms and plenty of freezing. T matured no pods.

M. Gorman, San Ardo, Monterey County.—Tangier pea grew only about two inches h had a few sickly blossoms but no fruit.

H. H. Gird, Fallbrook, San Diego County.—The tangier pea is probably too nice, a birds eat up vines and all. They grow thriftily.

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TAGASASTE—CYTISUS PROLIFERUS ALBUS.

ence was made to this plant in our report for 1885-6, and it ted that under favoring conditions it had become a tall shrub rd, woody stem and branches, and quite different from what we d from Von Müller's description of it as a "tall herb." If sub- o browsing by stock, it would, no doubt, make a more scrubby er growth, but it can hardly be considered as a forage plant in al acceptance of the term. For dry mountain lands it might be e as browsing, but experience, thus far, seems to indicate that it uch injured or repressed by heat and drought, and too suscep- frost to be generally valuable on wild pastures. Very many of ve shrubs are probably better than it, and could be more profit- opagated. But, as a rule, we do not desire to increase the rowth, but to introduce something more productive and satis- For the above reasons we conclude, from present knowledge, asaste has no particular value in this State. The following are from correspondents:

Bates, Brownsville, Yuba County.—Tagasaste sown in April, and watered, grew to es in height by September. Sown on dry land it germinated well, but perished ght afterwards.

oag, Boonville, Mendocino County.—Only one seed germinated. The plant is two I don't think it is of much value to this section, as we have too much brush

okes, Boonville, Mendocino County.—The forage plant, tagasaste, did well. We tive forage plant very much like it.

Haslin, Pino, Placer County.—I have not succeeded in growing tagasaste on unir- anitic land, though I have twice tried it.

d Plasse, Jackson, Amador County.—The tagasaste germinated a few seeds, but in the hot summer.

Messenger, Valley Springs, Calaveras County.—I planted some of the tagasaste seed t times and in different places, following instructions relative to scalding and . Those which I planted in the field I put in places where the fire had burnt es, so the grass and weeds would not interfere with their growth. After digging d well and planting the seed, I covered with brush, to protect the small plants. there was no late rain after the seeds were planted, some of them came up and e well without a drop of water, and I think, so far as I can see, that it will be e addition to our forage for stock in the dry foothills. I notice the rabbits have early every one of them, which shows that they appreciate them.

reve, West Point, Calaveras County.—The tagasaste did well.

Turner, Valley Springs, Calaveras County.—The tagasaste was planted in red foot- With no irrigation it came up and grew well, but did not stand our unusually n.

, Arroyo Grande, San Luis Obispo County.—The tagasaste plants are not growing ew ground. The tallest is about two feet high.

rick, Paso Robles, San Luis Obispo County.—Tagasaste has grown the first summer t of about five feet and very bushy.

Bird, Fallbrook, San Diego County.—Tagasaste seems to be injured too much on nd by frost to be of much account in such situations.

JERSEY KALE.

is a tall-growing collard, the seed of which was brought to us he island of Jersey by Mr. S. Wakeham, of Berkeley. It is grown on Jersey for cow feed. On our grounds in Berkeley it duced green feed at the rate of sixteen tons to the acre, starting uickly after cutting. Judging from the reports of some of our ondents, and the superior height which the plant attained with he weight of green fodder produced must be much greater than ures. The plant has also shown a much wider range of adapta- nan we expected. We did not anticipate success with it, except st lands and in regions of moderate heat. It seems to have over-

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stepped both these limitations, and it commends itself quite gener
as a source of vast quantities of succulent forage during the dry seas
Whether it will thrive on scant cultivation, such as too often is give
large areas of any plant, we are not assured, for we imagine that m
growers have thus far given it something like garden culture. For
family cow and for poultry it seems preëminently fitted to give, perh
more green fodder than can be secured with any other plant on the sa
area. The following extracts from correspondence show the wide ra
of the plant, and some of its habits of growth:

Thomas J. Pilkington, Trenton, Sonoma County.—Jersey kale on moderately enri
soil is a success. It furnished all the green feed I needed for my ducks and chick
which eat it greedily even when not confined. I shall grow it largely for poultry.

Isaac Lea, Florin, Sacramento County.—The Jersey kale grew splendily on my m
land at Napa Junction.

Howard Overacker, Centerville, Alameda County.—Jersey kale was sown in a warm, r
place in the hills back of Mission San José. It has grown well, being five feet hig
the middle of December. Stock seem to like it.

A. L. Bowden, Bitterwater, San Benito County.—Jersey kale, sown April 15th, had gr
to five or six feet high by the last of October without any irrigation. We consid
excellent for poultry. All kinds of stock eat it well.

M. E. McCormick, Easton, Fresno County.—Jersey kale grew to a height of eleven
and made most excellent green feed for fowls.

E. H. Cawley, Starkey, San Luis Obispo County.—Jersey kale did well, and, after cut
started again, and was two feet high at Christmas. I never saw anything more vigo

N. F. Frick, Paso Robles, San Luis Obispo County.—Jersey kale produces more feed
the same area than anything else we have grown.

H. Brundage, Montecito, Santa Barbara County.—Jersey kale has made a heavy gro
It still grows well after cultivating twice, and I think it will make an excellent fo
plant.

J. R. Giddings, Pasadena, Los Angeles County.—Jersey kale grew to a height of five
Stock eat it readily, but it requires more attention than sweet corn, and I do not t
it is so good.

S. J. Irwin, Nuevo, San Diego County.—Jersey kale, sown in rows, on pretty dry l
grew slowly, but lived all summer. and when the fall rains came it fairly ran up.
cutting it makes another head of leaves, and will yield enormous crops of fora
watered and manured.

Edwin Haffenden, Lakeside, San Diego County.—Jersey kale grew well without w
while Japanese wheat grass grew but little, because of drying out.

W. H. Frink, El Casco, San Bernardino County.—Jersey kale, sown in March, on mo
ately moist land, made a moderate growth without water.

SALT BUSHES—ATRIPLEX SP.

These Australian plants have been grown and distributed by
Station for the last ten years, and they are characterized, so far as
species have been determined, in our report for 1885–6. Correspond
do not say much about them, and the inference would be that they
not serve such good purposes here as accounts credit them with in A
tralia. On the grounds in Berkeley they grow thriftily without irr
tion, but the forage does not seem to be relished by stock to which
have offered it, possibly because the animals are too well fed otherw
We have made distribution with reference to a possible value in ther
feed for sheep and goats, but reports do not include any testimony
this point. The following are the only reports returned to us:

John Guttinger, Pescadero, San Mateo County.—I found the salt bushes very useful
I was in Australia.

B. B. Hogaboom, Franklin, Sacramento County.—The four kinds of salt bushes sen
grew well during the driest part of the year, but were cut down by winter frosts.

M. F. Gregory, Jenny Lind, Calaveras County.—I planted the salt bushes on bottom
badly covered with sand from mining debris. They grew well, though grievousl
back by rabbits. Two kinds bore seed, and volunteer plants grew in abundance.
kind seemed very attractive to fowls, which relished the small red berries produced

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TS FROM MISCELLANEOUS PLANTS SENT OUT FROM THE CENTRAL STATION.

By CHARLES H. SHINN.

tatistics of the work of the Central Station in sending out plants, uttings, scions, etc., receive mention elsewhere in the depart- reports. But the nature and extent of some of the more impor- tributions, as illustrated by letters from experimenters in various f the State, justify the following detailed account. It contains llusions to the outlying stations, but it is essentially illustrative vork of the Berkeley station, where the propagating houses are l, and all correspondence is conducted.

SEEDLING DATE PALMS.

rts received during the year from those who have planted the lms vary greatly in character, as will be seen by the following s, which refer to seedlings of the true date (*P. dactylifera*) grown t out from the Berkeley station:

reeman, Fallbrook, San Diego County.—Though received in poor condition, from shipment, they have grown several inches.

Lockstone, Jamul, San Diego County.—The palms are doing well, but grow very

Hansen, Anaheim, Los Angeles County.—The palms did not make much headway.

Spencer, Anaheim, Los Angeles County.—The palms are healthy and making good They were not in the least affected by the cold.

Robinson, Nordhoff, Ventura County.—The palms have as yet made no new growth, healthy, and I have no doubt they will succeed.

dage, Santa Barbara.—The two palms look well, but have made but little growth.

Dana, Nipomo, San Luis Obispo County.—One arrived dead. The other has done , and seems to be at home; it has grown about ten inches. I have also planted of dried dates, which seem to be doing equally as well.

, Arroyo Grande, San Luis Obispo County.—Both of my tree palms are alive, but ly have not grown any.

Burk, Mountain View, Santa Clara County.—The two palms did not take kindly nds at first, their leaves were so fragile; but seem now (September) to be getting ed. Though no higher, they are sending more leaves out, and I have hopes that make their homes with us.

elaney, San José, Santa Clara County.—The palms I potted are doing very well, hey have not made much growth. I will put them out in the fall.

Gates, Mountain View, Santa Clara County.—The two palms, which I planted out en ground, are looking very thrifty.

Swift, Oakland, Alameda County.—One of the palms lived, and has exhibited rdiness.

arrison, Danville, Contra Costa County.—One palm is growing tolerably well. The imen was destroyed by a gopher.

Stitt, M.D., Vacaville, Solano County.—They have all grown well. I have four. out four feet high. The soil is quite sandy.

ngenberg, Cupertino, Santa Clara County.—I gave them special attention. One ered, the other was not. The watered one nearly died. I withheld the water, s since improved in appearance. The other has done much better, made several d looks healthy, although it has not made any growth to speak of.

M. Vincent, Lockeford, San Joaquin County.—Though the tops of the date palms ed by the frost (of January, 1888), yet the trees are sprouting from the roots.

s Flanagan, thirteen miles northwest of Orland, Colusa County.—One of the date growing slowly but surely.

Miles, Penryn, Placer County.—The date palms have bulbs four times the size at heir receipt.

DeLamater, Newcastle, Placer County.—The palms are alive and doing well; about growth for the season.

C. Alley, Roseville, Placer County.—One of the date palms is living. In regard to ptability to this climate, I cannot state. I have lost many other much more rubs.

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Previous reports have given information about trees now growing in various parts of the State, and two seedling varieties have been fruited at Winters and elsewhere, and exhibited at horticultural fairs. As an ornamental lawn or avenue tree, the date palm (including the Canary Island species, *Phœnix Canariensis*) has a much wider range in California than has been ordinarily understood, and sooner or later it will be planted extensively for these purposes as far north as the head of the Sacramento Valley.

It may be gathered from these widely scattered observations that local situation makes very material difference; but further experiments are required to give definite results. The extracts given above are from only about one fourth of the letters received at this office, but they cover the whole ground. In a year or two more the trees will be fully established, and will grow rapidly. One of the most satisfactory of recent plantings of the date palm for ornament only, is that of Don Juan B. Gallegos, at the Mission San José, Alameda County. He has about fifty large trees of the wild date now beginning to fruit. They stand in grass, and receive constant irrigation. The most extensive planting in Alameda County, however, has been done by John Rock, at Niles, where the date is used for avenues.

THE PERSIAN DATE PALM.

The successful cultivation of the date palm of commerce has long been predicted as among the probable things in California. A short time ago a writer in the New York "Evening Post" urged that there was an opportunity for the investment of capital in date groves in portions of California and Arizona.

During the year 1890 the culture of improved varieties of date palm received considerable encouragement in California. Public interest was first aroused by a valuable importation of named varieties from Persia, the first ever received in the United States; and many letters were received by me from persons who wished to secure plants. The limited number obtained, and also the great importance of the experiment, necessitated the planting of the whole number of dates at the two experiment stations best suited to this tree.

A letter received from Professor Van Deman of Washington, gives all the details necessary about the Government importation of dates, and also of citrons. He writes as follows, under date of October 11, 1890:

I have this day started the imported date trees, mentioned in our previous correspondence, by way of the Southern Pacific Railway. We have been keeping them here about a month longer than was expected, because we found it very difficult to destroy the scale insects which came with the plants from Africa. The Entomological Division has been treating them with kerosene emulsion, and finally a spraying of resin solution. It is now thought that the insects are all killed, but I will warn you to be on the lookout, and if anything of the pest mentioned should appear you will know what to do.

I have sent a full set of all the varieties to the station at Tulare, in care of Mr. Juliu Forrer, the foreman. The names of the trees are as follows: *Amhat*, *Nakleh-el-Pasha*, *Seewah*, *Hazaneh*, *Zeb-el-Abed*, *Sultaneh*, *Amreeyeh*, *Rasheedeh*, and one male plant. Also *Deglet Nour*, *Rars*, and *M'Kintichi*.

To the station at Pomona were sent nine trees, being one each of the following varieties: *Amhat*, *Nakleh-el-Pasha*, *Seewah*, *Hazaneh*, *Zeb-el-Abed*, *Sultaneh*, *Amreeyeh*, *Rasheedeh* and one male plant. It is not necessary to give you any directions regarding their planting.

There are three varieties of which I had but three plants each, and one set of these went to New Mexico, another to Arizona, which, of course, only permit the sending of one to your State, and I thought that Tulare was the proper place to send it.

I also sent to Pomona a box containing citron trees, which I obtained from Catania, in

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These are the choicest varieties that could be found there, and were budded at
ial order. There are six trees of *Cedro Vero*, which is a variety bearing rather
uit, but very good in quality; two of *Testa di Turco*, two of *Pereltone*, and two of
ana, making twelves trees in all. These you will know best what to do with, but
se that you will set them out at Pomona and propagate from them.
ink that they are entirely free from insects, as they have been kept under strict
nce last spring.
had numerous applications for plants of both the date and citron, but of course
mpossible to supply them, and I have now already turned over several of these
ions to you, and will continue to do so. I think the date trees have been wisely
both in your State and in Arizona and New Mexico.
olony of the plants is at National City, California, one at Yuma, Arizona,
at Phœnix, and another at Las Cruces, New Mexico. A few of the tubs con-
ouble plants, or, rather, two plants, and I have thus been able to order a division
such cases, and these extra plants—four female and one male plant—will be
ndio from National City, and placed in the care of the Southern Pacific Railroad
I know that you will wisely control the distribution of the young plants which
grown; but in the cases where colonies have been placed in the hands of private
als, an agreement has been made in writing and properly certified, giving this
ent entire control of the distribution of the young plants. They have been pro-
public expense and are the property of the people, and shall be placed in their
Trusting that the plants will reach you in good condition, I am,

Very respectfully,

H. E. VAN DEMAN,
Pomologist.

s at Tulare Station a few days after the arrival of the plants men-
From Tulare I proceeded to Pomona, where the new station was
ginning operations. Mr. K. McLennan, the newly appointed fore-
ccompanied me. The dates were received at both stations in fair
on, excepting that the *Deglet Nour* and *M'Kintichi* were almost
I investigated the matter, discovering that the plants of these
ere almost without roots—mere "suckers" planted in red clay.
to be expected that these would not survive, but by constant
on the foremen of the stations are likely to save the entire impor-

palms at Tulare are planted in sandy soil southwest of the build-
hey are set in a circle, with the male plant in the center. A few
ts can be expected from the larger plants in two or three years.
nona the palms are in front of the station building, near the
and will constitute one of the most striking features of the station.
ng the present summer (1891) a fair growth has been made, and
ms can be considered established at both Tulare and Pomona.

THE HUASCO GRAPE.

following extracts from reports received during the past two
rom several seasons of shipments of Huasco grape cuttings will
o show how widely it has been distributed by the University,
o something of its success:

. Hall, El Cajon, San Diego County.—In 1888 I received a couple of rooted vines
uasco grape. I planted one of them amongst the cuttings of Muscat of Alex-
n my vineyard, marking the place. This summer (1890) they have borne for the
e. I have just picked some bunches of very nice grapes from them. I cannot
sh any difference in growth, foliage, or habit between the Huasco and the
If anything, the Huascos are a trifle smaller and not quite so sweet as the
Muscats. As yet, I fail to see any advantage over the Muscat vine.
Freeman, Fallbrook, San Diego County.—Although the Asiatic cuttings died from
shipment, the Chile raisin grape grew several inches the first year.
h, Riverside, San Bernardino County.—Four of the Huasco cuttings set out in
v fairly well. They have not yet fruited.
Musser, Pomona, Los Angeles County—The grape cuttings all grew except three.
tell much about them until they bear fruit.

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Wm. Chappelow, Duarte, Los Angeles County.—All of my Huasco grape cuttings grew. They were planted in sandy soil, and have not made much growth.

H. Ellery, Carpenteria, Santa Barbara County.—Of the ten Huasco grape cuttings only one rooted, and that I transplanted, so I can give no information of any importance. [This in 1889; no later report.]

D. M. Dimmick, Carpenteria, Santa Barbara County.—The Huasco grape first bore in 1887, and remarkably well for the second year from cuttings. It has done well in subsequent seasons, 1889, 1890. The berries are very large; some measured one and one eighth inches in the longest diameter, by seven eighths of an inch across. The flavor is slightly better than the Muscat. The growth of the vine is good.

Geo. Weiss, Creston, San Luis Obispo County.—Of the five Huasco cuttings three remained alive, and these I transplanted in 1889 to the vineyard. In comparison with the Muscats transplanted at the same time, they have made a little better growth.

E. K. Thoits, Nipomo, San Luis Obispo County.—The Huascos have done well. Three fourths of them started, have made good growth, and are now bearing.

Mrs. H. McLaughlin, Avenal, San Luis Obispo County.—It was so late when we received the grape cuttings that only the Huasco raisin of Chile grew. I think this will be a great place for grapes and fruit in general. We do not irrigate.

Michael Gorman, San Ardo, Monterey County.—The ten Huasco grape cuttings have grown very well, and are bearing finely.

John Wandell, Hollister, San Benito County.—The Huasco grape has made a fine growth.

Henry F. Speetzen, Watsonville, Santa Cruz County.—Seven of the Chile grapevines are alive and doing well. They are in moist, sandy soil.

Robert G. Adair, Alma, Santa Clara County.—I grafted the Huasco grape upon the Riparia eighteen months ago, and have no fruit this year (1888).

W. T. Reid, Belmont, San Mateo County.—My Huasco vines have two bunches on them. The berries are uneven, but the vines are yet too young to report upon.

Robert Haste, Clayton, Contra Costa County.—The Chile Huasco grape only averages fairly well with the Muscat of Alexandria.

F. Barbour, Clayton, Contra Costa County.—The Huasco grape cuttings which we put out are nearly all growing finely, and I will report to you further when they come into bearing.

L. I. Fish, Martinez, Contra Costa County.—One Huasco grape is living and bears well. It differs but little, if at all, from the Muscat of Alexandria.

George Harvey, Forestville, Sonoma County.—Cuttings of the Huasco grape, planted in 1887, grew ten feet in the season of 1888, and bore some. It seems to me to be identical, or nearly so, with the Muscat of Alexandria.

T. C. Starr, Santa Rosa, Sonoma County.—Nearly all the grape cuttings are growing.

J. H. Adams, Occidental, Sonoma County, writes that nine of twelve cuttings planted February 11, 1889, in red soil, are alive, and have made a medium growth. "I had to take a great deal of trouble, as they were in poor condition when received."

Samuel Turner, St. Helena, Napa County.—Only two out of my dozen Huasco cuttings are alive, and they are making but a poor growth. We had little rain in the spring of 1889, and that little was followed by the drying north winds.

W. A. McKaig, Little Stony, Colusa County.—In my vineyard are Black Hamburgs, Muscats of Alexandria, Rose of Peru, and some unknown vines. The Huasco outyields the others of the same age. It grew about five feet. The grapes were about the size and flavor of Muscats. In general, I may say that grapes do well in this section.

W. H. Brown, Maxwell, Colusa County.—I received a dozen cuttings of the Huasco raisin grape three years ago. I succeeded in growing five of them. They will commence to bear this year (1889). They are making a vigorous growth. I am satisfied they will be well adapted to our hot, dry climate.

Jas. Wheeler, Oroville, Butte County.—The growth of the Huasco grape is about two feet the first season from the cutting.

G. B. Rodgers, Mooretown, Butte County.—Of the dozen Huasco grape scions three have lived, and made good growth. They are perfectly free from all insect pests.

S. P. Hicks, Delta, Shasta County.—None of the Huasco grape cuttings grew. They were lying in the Post Office a week, and became too dry.

C. M. Richards, Cottonwood, Shasta County.—The cuttings planted on hill land of a gravelly nature, unirrigated, made a splendid growth, notwithstanding the very dry summer of 1888. I can see no indication of phylloxera here. I believe the Huasco is one of the very best varieties. It has done better than any other I have, among which are the Flame Tokay, Rose of Peru, Muscat, Black Bishop, and others.

Clara Wood, Sciad, Siskiyou County.—Four of the Huascos rooted, but all save one froze out during the winter of 1887-8. That one was on dry ground, and is doing well. It fruited in 1889 and again last year.

C. Brower, Bakersfield, Kern County.—Huasco grape scions were grafted (1885) into the roots of the Muscat of Alexandria and the Emperor. The former, on a dry, sandy soil, were lost through want of attention and carelessness of my employés; the latter, on low, moist land, and trained upon an arbor, made a vigorous growth from the first, and in 1888, according to my recollection, were about two inches in diameter at the ground. They have borne fruit since 1887. I have been unable to distinguish any difference whatever between the fruit and that of the Muscat of Alexandria on the same arbor. No phylloxera has been reported in this locality, and mildew is not common, except on the Isabella.

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ing, Fresno.—The Huasco cuttings are rooted, and I will report in time if desir-
aisins.
Witthouse, Fresno City.—There are eight out of the twelve Huasco vines grow-
y made branches from thirteen to thirty-three inches long and look splendid—
s the majority of Muscat cuttings I set out at the same time.
add, Atwater, Merced County.—The Huasco grew thriftily in 1887, and fruited
888.
Vest, Elliot, San Joaquin County.—My Huascos were planted a year ago last
nd fruited this season. I think they will prove valuable here. The growth is
ust than that of the Muscat; the fruit ripened a little earlier, and the musk
nore pronounced. Still, they strongly resemble the Muscat. In fact, if planted
I think it would be very difficult to tell one from the other. Having but few,
e planted in an exceptionally favorable location, which may account for the
e in growth.
almer, Sacramento.—The Huasco grape is doing well. I have raised a few roots
scions. I grafted the scions into a Zinfandel vine, and they have made a heavy
I think it will make a first-class raisin.
arss, Placerville, El Dorado County.—The grape cuttings (two dozen) died, except
ey are doing pretty well.
Messenger, Valley Springs, Calaveras County.—The Chile raisin cuttings have about
of them grown, but slowly. I think they will come out well next season.
Maslin, Pino, Placer County.—As to the Huasco cuttings I have nothing to
vorably. I cut the cuttings down to eyes and potted them, transplanted to
ed ground, and they have lived, and that is all. My soil is granitic, and four
feet above the sea.
Pillsbury, Auburn, Placer County.—The Huasco grape cuttings made a slow
while Muscats planted the same day, in a row adjoining, made a strong growth
ed the first season. Huasco did not bear until the second season.
McMenamin, Dobbins, Yuba County.—Ten of the eleven Huasco cuttings received
ew very vigorously, and they have produced fine grapes this year (1889). They
ery fine quality and flavor. Grapes of all kinds do well here, ripening from the
July until late in November. Phylloxera is not known around here.
alker, Olancha, Inyo County.—The grapevines planted in 1889 have done well.
o transplant them this fall.

preceding reports are classified according to location. First
ne southern counties; next the Coast Range valleys; next the
ento Valley and Siskiyou; then the San Joaquin; lastly the
oothills. The same general order is observed in reports upon
lants, so as to render comparison more easy.

rst view, our correspondents give rather too much apparent
is to the likeness between the Muscat and the Huasco. This
s is most marked on young vines; with age the distinctive feat-
the Huasco develop. The cluster is shorter, more pointed, and
mpact than that of the Muscat. The grape is more free from
and sets better in many districts. It is a well known fact that
ins of this grape, as grown in Chile, bring the highest price paid
raisins. More extensive vineyard planting can be confidently
ended, especially in districts where the Muscat is an uncertain
as in portions of San Diego and the Sacramento Valley.

ll be observed that especial success is reported from Santa Bar-
an Luis Obispo, Colusa, Shasta, and Yuba. The high flavor of
pes has been noticed by many of the experimenters. The excel-
owth of young vines also attracts attention. Raisin-making
be the next step in every locality on the list.

Huasco grape has been a subject of much discussion. Its similar-
he Muscat of Alexandria, as noted by most of the preceding
rs, was early recognized, and the too hasty conclusion that it
little value found its way into print. In reality, however, experi-
vith the Huasco grape confirm the belief that it will bear better
districts than the Muscat does, and that it may thus serve to
the raisin districts. If a place is found where, as in Chile, it is
early seedless than the Muscat, its value will be much increased.

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At Paso Robles station the vineyard contains few more promis early bearers than the Huasco. The present season of 1891 was parti larly favorable. The experimental vineyard makes a fine appearar and the greater part of the vines are carrying fruit. There will be su cient for tests of many new varieties.

In the Paso Robles district many planters have failed with the Mus grape. It is said to bear poorly, and its bunches are uneven—enti useless for raisins. Hon. J. V. Webster tells me that a safe raisin gr could be planted on a large scale in the Estrella region, but that Muscat will not do. In such cases the Huasco is certainly worth a tr

THE OLIVE.

Extracts from a large number of letters received from various part California illustrate the widespread interest felt in this valuable tree. a few years more the olive trees at the stations will be large and in b ing. Cuttings and scions can then be distributed on a much larger sc The nurseries are gradually reducing the cost of budded olive trees, even now the cost of a few trees is quite within the means of every la owner.

The following reports have been received:

D. B. Hoffman, Helix, San Diego County.—The Nevadillo olive trees are fine, large now. They were irrigated four times, from April to November, each year. This pa the State is superbly adapted to the olive, in my opinion, and in time will supply al oil and fruit that our home market can handle. The two olive trees were two and a or three feet high two years ago. They are now two and a half and three inch diameter and six and seven feet high. The growth is very thrifty and hardy, an clean and beautiful as could reasonably be desired.

Alfred Wright, Pomona, Los Angeles County.—I planted about ten acres of Manza and Nevadillo blanco olives, which have done well, and are beginning to fruit.

T. J. Lanigan, San Ardo, Monterey County.—I set two hundred Picholine olive trees year old. They put forth new leaves, but did not make any progress. They nearl died this summer. I noticed that they died after irrigation.

Alex. Manning, San Rafael, Marin County.—I received one Nevadillo and one Ma nillo. Both were of the same size, were planted together, and have received the treatment. The Manzanillo has made far the larger growth. The extreme cold o winter of 1888 harmed the Nevadillo. Its leaves first cracked, then turned black finally dropped off. The tree stopped growing for a long time, but has now fully r ered. The Manzanillo seemed to grow whilst the other suffered. Its leaves kept g and bright, and it was continually making new wood, until it is now two feet hi than the Nevadillo. Both promise to fruit this year (1891).

Wm. Sale, San Rafael, Marin County.—The olives received in 1888 (Manzanillo and N dillo) have made a rapid growth. They are now five feet high, with plenty of st branches, forming a head three and one half feet in diameter.

G. P. Rixford, San Francisco.—The olive trees (Manzanillo and Nevadillo) sent n the winter of 1886-7 are both doing well and have made a fine growth. I expect the fruit some by 1892, possibly this year (1891).

J. A. Benton, M.D., Oakland, Alameda County, wrote in 1889: "The Manzanillo Nevadillo trees have made a moderate growth. The soil, a cold clay, is not espec good, and the exposure is northwest."

F. Spangenberg, Cupertino, Santa Clara County.—The Nevadillo olive made a vig growth of three feet in one year on an unirrigated hillside.

Mrs. E. Burk, Mountain View, Santa Clara County.—The Picholine olives, which only six or eight inches high when we planted them (February, 1887), now average feet (September, 1889).

Robert G. Adair, Alma, Santa Clara County.—I have some Mission olives that planted three years old two years ago, and they are doing well, although without ir tion or care beyond cultivation. More than 50 per cent were sun-scalded, and grew s from below.

W. G. Ellis, Alma, Santa Clara County.—The five Nevadillo olive trees sent me in 1 planted in a nursery row until last spring. While there they grew to the height of five though not branched much, but were very healthy and strong, notwithstanding the f of 1887 and 1888. In the beginning of February, 1888, I had them moved to perma places, when three of the five died from the top down. This, I think, was due to the

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they were handled while transplanting. However, I noticed that two of the
w again from the roots. That the location is adapted to the successful cultiva-
ne olive I feel sure, as the soil, the climate, and everything else seem to me to be
vor. I have some hundreds of both Mission and Picholine that have made a
l growth, though cultivated but little, and had both heavy frost and very dry,
her to contend with.

s, Los Gatos, Santa Clara County.—Two olives (Nevadillo and Manzanillo) received
s and a half ago are now doing finely, having grown about two feet last season.
re extremely small, and were, unfortunately, exposed to a remarkable snow-
hen set out. The trunks are now over one inch thick.

Vittenmeyer, Martinez, Contra Costa County.—The olives (Nevadillo) were planted
d loam, and occasionally watered. They have continued to make a thrifty
not being affected by the cold.

n P. Edwards, Penn's Grove, Sonoma County.—The Manzanillo and Nevadillo olives
well and were not injured by the cold, though unprotected. Unfortunately, the
rough carelessness, got into the orchard, destroyed the Manzanillo and damaged
, but it revived and is growing rapidly. The hardiness of these olives deter-
e to devote twenty acres to their cultivation, and I set out two thousand of the
e, which are doing very well, barring the loss of some seven hundred from get-
ed in coming from the nursery.

nziker, Cloverdale, Sonoma County.—I report with great pleasure that both olive
anzanillo and Nevadillo) are growing finely without water.

mith, Englewood, Humboldt County.—The olive plants which you sent to Mrs.
e made about six feet of growth, but are very spindling. They have still to be
support. They stood the winter's cold very well.

Russell, Anderson, Shasta County.—The olives (Nevadillo and Manzanillo) received
, 1887, were properly planted, one on gravelly and one on red, rocky hill soil,
ched with sheep manure. Receiving no irrigation, the growth was very satisfac-
ng at least two feet the first season. The extreme cold in January killed the tops
ranches, but by removing the injured parts they started a new and vigorous

Pillsbury, Auburn, Placer County.—The Nevadillo olives made about three feet of
he first season, but in January, 1888, were killed to the ground and grew again.
ow about four feet high. A three-year old Picholine olive on the same ground
jured.

Valentine, Lotus, El Dorado County.—The two olive plants made an excellent
luring the season, but were killed by the cold weather of 1887–8. Two trees of
ion olive, five years old, were not at all affected by the frost, making a fine
f three and a half feet, and fruiting in 1888.

D. Enas, Napa.—The Nevadillo olives did very well. I have been advised to
ves here where it is too rocky to plow, as the rock and soil are favorable to their

eynolds, Kelseyville, Lake County.—The Mission olive cuttings all died, or did not
ots.

emon, Valley Springs, Calaveras County.—I planted a small lot of olives on newly
haparral hill land, having a red clayish soil, and having a rotton slate bedrock
ath. The depth of soil was eighteen inches to two feet, and could be pulverized
ly by cultivation. I cultivated well, and mulched the trees in June. I had
nall trees in large holes, and the results of my attention were that 95 per cent of
trees lived and are making a thrifty growth without irrigation.

Palmer, Sacramento.—Of the two Nevadillo olives, one died infected with scale;
is doing finely. I have put out several cuttings, and layered a few branches.

Lea, Florin, Sacramento County.—The Nevadillo and Manzanillo are making a
growth, but have not fruited yet.

Greene, Walnut Creek, Contra Costa County.—The olive trees (Manzanillo and
o) are doing well.

Ladd, Atwater, Merced County.—The olives (Manzanillo and Nevadillo) grew well
time of planting in 1887. They grew about two and one half feet by January,
en they were completely killed.

ring, Fresno.—The olive trees are doing well.

e reports are full of valuable hints. The gentleman from San
whose trees died, probably irrigated heavily in hot weather. Large
re liable to suffer or perish under such treatment. With care, as
case reported from Santa Clara, sun-scalded olives will sprout
from the roots. It looks as if the Manzanillo is hardier than the
illo, from the reports of the cold winter of 1888. The Mission is
tly more hardy than either. Local conditions, however, vary so
that no one in the olive districts need hesitate to plant the finer
es on a small scale, at least. Both the Nevadillo blanco and the
nillo succeeded fairly at Anderson, Shasta County; better, in fact,
n some cases reported from counties farther south.

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THE CAMPHOR TREE.

Reports from the camphor trees sent out are almost uniformly favorable, and indicate that this tree is already well established in popular esteem. There have been but few failures that can be attributed to frost. The tree thrives on a great variety of soils, and over the larger part of the State. The most serious cause of failure is evidently the blighting north winds, and any extremely hot weather. All who used proper precautions in shading and sheltering until the trees were thoroughly established, have managed to save them.

The station experience can be briefly summed up as follows: At Tulare City the camphor tree has made rapid growth and is an entire success. At Amador it grows well and stands the hot summer sun. At the new station for South California, Pomona, two camphor trees were caught by the north wind in March, and blighted in exactly the way described in several of the following letters. They had just been planted, and the labor of planting out the new orchard prevented them from receiving any attention, or they could have been saved. The camphor will undoubtedly thrive wherever the orange does, but it requires care at first. More trees will be set out at Pomona next spring.

Reports from different parts of the State follow, selected from a much larger number of reports received in answer to letters of inquiry:

John Hudson, Escondido, San Diego County.—The camphor tree looks well.

Abner L. Butterfield, Escondido, San Diego County.—The camphor trees are all dead except one I let Mr. Hudson have. There was a little alkali in my land.

P. S. Russell, San Jacinto, San Diego County.—After protecting the camphor trees from the hot sun, they made a fair growth.

D. M. Dimmick, Carpenteria, Santa Barbara County.—The camphor trees are growing well.

Alfred Wright, Pomona, Los Angeles County.—The camphor trees made a very good growth—two feet. The spring of 1890 was cold and late.

Thos. Spencer, Anaheim, Los Angeles County.—The camphor trees are doing nicely. They seem to thrive with as little care as anything in the garden.

Robert Hansen, Anaheim, Los Angeles County—The camphor trees are growing nicely.

Nathan W. Blanchard, Santa Paula, Ventura County.—The camphor trees, planted last spring, have made very little growth; some have died.

Richard Robinson, Nordhoff, Ventura County.—The camphor tree grew about ten inches the first year after planting.

E. W. Harrold, Saticoy, Ventura County.—The camphor trees grew nicely with little irrigation.

Frederick Allbright, Estrella, San Luis Obispo County.—Three of the five are living. The extreme heat and scantiness of surface moisture were severe on them, though I have watered them repeatedly.

Carroll S. Browne, San Luis Obispo.—The camphor trees (fifteen) received from you last winter all lived and made a good growth. I think they will do well here.

James Dearden, Paso Robles, San Luis Obispo County.—The camphor trees I planted with great care for shade trees, and they seemed to do well for a week or two. We had a late frost that killed them down to the ground. They put out new shoots again, but they finally died.

Frank Dana, Nipomo, San Luis Obispo County.—I planted three camphor trees. One died. The other two have done very nicely, and made about one foot of new growth the following year.

H. M. Maxwell, San Miguel, San Luis Obispo County.—The camphor trees, irrigated and well cared for, seem to be making a good, healthy growth.

E. K. Thoits, Nipomo, San Luis Obispo County.—The four camphor trees are all doing well. They have formed nice tops and look well. They have grown fully one foot, and are very stocky. We think a great deal of them for their beautiful leaves.

Mrs. G. W. Gordon, Salinas City, Monterey County.—All the camphor trees died. I think they got too dry while coming, as they were delayed in the office a number of days.

Isaac Dakin, Laurel Glen Fruit Farm, Santa Cruz County.—Four of the camphor trees died, the bark turning black just above the ground, and the tree slowly turning yellow till dead. The other one is all right and growing slowly.

W. G. Ellis, Alma, Santa Clara County.—Three of the five camphor trees are alive, two of them having made a large growth, one of them a shade under five inches. The third is at a standstill, although receiving the same treatment as the others.

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eckwith, Los Gatos, Santa Clara County.—The camphor tree seems perfectly hardy, ɔid grower.

. Sanders, Gilroy, Santa Clara County.—Some of the camphor trees died. The th was nine and one half inches. They had but little care. The soil is a dark gravel. They were watered about once a week.

Burk, Mountain View, Santa Clara County.—Of the five camphor trees I gave ny neighbors, but they did not succeed in getting them to grow. One of those erved I planted on the south side of the house, sheltered from those heavy have, and also gave it a little shade from the burning sun; that one is growing ; well. The other I planted in front of the house, which has a northwestern ; and though protected, it succumbed to a blighting north wind, which scorched ; as if they were burnt.

Swift, Oakland, Alameda County.—The camphor will make a handsome orna- ee. The plants all lived, and have exhibited much hardiness.

Haste, Clayton, Contra Costa County.—My camphor tree is doing well.

arrison, Danville, Contra Costa County.—I am sorry to say that, notwithstanding ention in the shape of water, cultivation, and shade, my five camphor trees uccumbed to the extremely hot weather.

our, Clayton, Contra Costa County.—We have succeeded in making two of the trees live; they look healthy and are thriving.

arr, Santa Rosa, Sonoma County.—The five camphor trees are alive, and have d growth.

S. Leber, Santa Rosa, Sonoma County.—A part, only, of the camphor trees are They remained green for several weeks after planting, until a north wind leaves, and they never started again. Those which survive look well. They anted in rich soil, and have had water only occasionally. This seems to have a long, dry summer (1889) that a great many plants, which usually grow very ve only just managed to live.

layden, Sebastopol, Sonoma County.—The camphor trees are doing well. They e a growth of about eight or ten inches without any irrigation, and they are esh and healthy. The camphor tree is a beautiful thing. I had one at Novato, unty, that at four years of age was eight feet high, and spread out in propor- s very desirable. The foliage is always bright and clean and never troubled ets.

oag, Boonville, Mendocino County.—Three trees with light-colored foliage lived They seem quite hardy, and stood the frosts well. Two trees with dark- liage were very tender, and the next spring's frost killed them.

cks, Delta, Shasta County.—Two of the camphor trees are growing nicely now. e killed down by the sun, but have sprouted from the roots, and are now six gh. I think the sun would have killed all had I not shaded them with shakes.

ansen, Redding, Shasta County.—The camphor trees all died, save one which rom the root. They all did well at first, but were all caught, one after another, of black blight at the top of the ground and descending to the root.

aylor, Ophir, Placer County.—The camphor trees are one half of an inch thick d over four feet high, and look fresh and hardy. The soil is not extra good.

aylord, near Auburn, Placer County.—The camphor trees have done remarkably

Bonds, Newcastle, Placer County.—My trees remained at the railroad station were dried out badly. Only two started out of the lot. I buried them in the a week before setting them out. They have made a fine growth.

C. Alley, Roseville, Placer County.—The camphor trees all died. The north wind eeps through here killed them. I have lost many other much more hardy s way.

lespire, Proberta, Tehama County.—Out of four camphor trees, I have but one

lark, Anthony House, Nevada County.—Of the five camphor trees, we found one rrival, and one has died since; the rest are doing well to all appearances, hav- a growth of six inches.

hompson, West Butte, Sutter County.—I planted the five camphor trees in sandy, il without water. They grew finely and looked well till the last of July, 1889, y died. If I had irrigated, they would have lived. They had no insects

eeler, Oroville, Butte County.—The camphor tree will grow here as well as the ts growth for the season is about eight inches.

afferty, Wyandotte, Butte County.—The camphor trees grew until the warm ame, then they all died. Some had borers in the roots, but some did not. ied from the top down.

ills, Marysville, Yuba County.—I could not make the camphor trees grow.

Pyle, Elk Creek, Colusa County.—The trees stood the winter splendidly, but the er through July and August killed all of them. The sun would kill each new fast as it appeared. I am quite well satisfied that the camphor trees will not climate.

Montour, Williams, Colusa County.—The camphor tree is a hardy and rapid re.

Flanagan, thirteen miles northwest of Orland, Colusa County.—Of the five camphor ved, but three are growing. The wet weather which prevailed when they were

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received, made us unable to plant them until late in the season. Then dry weather set in almost immediately.

Wm. Walker, Olancha, Inyo County.—The five camphor trees grew finely until about August 20th, when they began to decay about two inches from the root, and I cut them off. They have not sprouted again.

F. M. Gaffney, Middletown, Lake County.—I received five camphor trees. Four of them have made no growth at all, although they are alive and look healthy. The fifth has grown three inches. They have had no irrigation, but I have cultivated them three times. The coldest weather since trees have been planted was 25 degrees Fahrenheit.

Richard Wylie, Napa, Napa County.—The camphor tree stood the hard winter of 1887-88 and that of 1890 without the least injury, and is growing luxuriantly.

H. W. Turner, Valley Springs, Calaveras County.—The camphor trees, planted in red foothill soil and irrigated, are growing slowly.

H. A. Messenger, Valley Springs, Calaveras County.—The camphor trees have grown finely, and appear to be at home in this soil and climate.

G. E. Ladd, Stockton, San Joaquin County.—The camphor trees, planted in black adobe, are growing rapidly.

A. J. F. Witthouse, Fresno City.—The camphor trees made a few leaves at first, but by the beginning of April a black spot appeared on the stem of the trees about two inches above the ground. In a few days the spot made a black ring one inch or more around the tree. The top remained green about two weeks, and then died. The roots sent up small sprouts about two inches high, and then died. One and two-year old walnuts were killed in the same way. The soil is heavy, with considerable alkali.

W. F. Stewart, Tulare City.—Of five camphor trees four died. I believe they had too much water.

The reports cover almost the whole State. The necessity for a full knowledge of local conditions is shown by the report from Paso Robles, where frost killed the trees. This is on low land near the river; on the bluffs the camphor does well. In places like Fresno, the sun-scald is bad; trees ought to be sheltered for a few years. The bark of the camphor is sensitive to the extremes of temperature; a low head should be formed by pruning, or it should be planted in shrubbery or orchard, already established, in places where its hardiness is a matter of doubt.

THE CAROB.

No tree distributed by the stations is more likely to make a popular shade and ornamental tree for dry, rocky situations than is the true carob of Southern Europe and Asia Minor. Aside from the fruit, whose well attested economic value ought to induce more planting, the tree is of striking and attractive appearance. In rich valley soils it does not bear early, nor yield so abundantly, as in its own home, the warm, rocky hill country. Its culture, however, will not become general until after that of the olive and the fig, which offer better returns.

The most instructive of the following reports is one from San Diego County; no cultivation, no water, and planted on *mesa* land—but the trees did better than any others so far as heard from;

B. J. Rice, Fallbrook, San Diego County.—The carob trees are all alive and seem to be entirely hardy here. The largest one is eight or ten feet high. They are on high land, and have had no water or cultivation.

Wm. Chappelow, Duarte, Los Angeles County.—Five years ago I received samples of carob trees, which stood the first and second winters, but were killed by the heavy freeze of 1888.

D. H. Temple, Los Gatos, Santa Clara County.—The carob trees grow slowly, but are not affected by the frosts.

G. P. Rixford, San Francisco.—The carob trees are doing well, but I find require some protection from frosts while young.

Francis G. Smith, Healdsburg, Sonoma County.—In the spring of 1886 I received five carob trees. They did well and made a growth of about two feet, but the cold weather of 1888 killed them, root and branch.

Thomas Mahoney, Marysville, Yuba County.—My carob trees that were growing nicely were killed by the frost.

Isaac Lea, Florin, Sacramento County.—The carob trees are growing, but slowly, although I water them.

Miss C. M. Vincent, Lockeford, San Joaquin County.—Though the tops of the carobs were killed by frost, the trees sprouted from the roots and are doing fairly.

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THE CORK OAK.

is worth while to push the culture of the cork oak of Spain, particu-
in the Sierra foothills. The larger part of the State is eminently
ed to oak plantations, as the success of the English oak shows; but
that is better adapted to the coast region, the cork oak will prob-
grow faster in warmer districts. But the cork oak is very hard to
plant. Even the English oak does best when removed at only one
An acorn planted where it is to remain, will often outgrow the
planted yearling. The cork oak is even better adapted to seedling
ations. Once fairly rooted, the cork oak will grow more rapidly
successive year.

r *L. Butterfield, Escondido, San Diego County.*—The cork oak trees are all dead.
was a little alkali in the ground.
Russell, San Jacinto, San Diego County.—The cork oak began to grow in the spring,
the hot weather approached they all died.
am *Chappelow, Duarte, Los Angeles County.*—My cork oaks planted in sandy soil
ry thrifty and nice, and made a growth of nine inches the first year.
d *Wright, Pomona, Los Angeles County.*—The cork oaks died. The spring was cold
e.
t *Hansen, Anaheim, Los Angeles County.*—The cork oaks are growing nicely.
. *Dimmick, Carpenteria, Santa Barbara County.*—The cork oaks are growing well.
M. E. Lyman, Santa Ynez, Santa Barbara County.—The one cork oak is doing well.
an *W. Blanchard, Santa Paula, Ventura County.*—The cork oaks were carefully
d, but made very little growth.
ard *Robinson, Nordhoff, Ventura County.*—The cork oaks made a growth of twelve
the first season.
ll *S. Browne, San Luis Obispo.*—One cork oak is alive, but has made a very slow
.
. *Maxwell, San Miguel, San Luis Obispo County.*—The cork oak trees are making a
ut normal growth, about the same as wild native oaks of the same size and age on
s.
rbour, *Clayton, Contra Costa County.*—The cork oaks did not thrive. I think the
son is too much for them. We do not irrigate.
Harrison, Danville, Contra Costa County.—Two of the four cork oaks have survived,
looking very weak. I am strongly of the opinion that had the oaks been stouter
they would have succeeded in fighting their way through a very untoward and
season.
Stitt, M.D., Vacaville, Solano County.—The corks have all grown well.
Marshall, Sebastopol, Sonoma County.—The oak trees received in 1889 are still alive
owing slowly.
ss, *Auburn, Placer County.*—The cork oak made a growth of nine inches, and looks
ly well. In Forest Hill, Placer County (altitude two thousand five hundred feet),
e raised from seed, planted about 1855, and it is now about forty feet high.
. *Gaylord, near Auburn, Placer County.*—The cork oaks have done remarkably well.
DeLamater, Newcastle, Placer County.—Two of the cork oaks are living and doing
They made only about one inch growth.
Taylor, Ophir, Placer County.—The cork oak trees are fine and rapid growers, one
sent out a limb twenty-two inches long.
Alderman, Smartsville, Yuba County.—Two of the small cork oaks I planted near
gation ditch, but they failed to respond. The other two, planted in the potato
started nicely after a time, but the most promising one gave out; the other lives,
crubby.
las *Flanagan, thirteen miles northwest of Orland, Colusa County.*—One of the cork
growing. It has made a growth of about six inches. The others died from a too
lay in setting out.
el *Turner, St. Helena, Napa County.*—Three of the four cork oaks started to grow.
the three died in a hot spell; the other two are looking well. I keep hoeing
them to keep the soil loose.
Lea, Florin, Sacramento County.—The cork oak and nut-bearing trees are doing well.
Ladd, Stockton, San Joaquin County.—The cork oaks, planted in black adobe, are
poorly.
F. Witthouse, Fresno City.—One of the cork oaks kept alive until the middle of
hen died all at once; the others did not start.
as *Jacob, Visalia, Tulare County.*—There is a large cork oak tree in this town, but
never seen any acorns on it.

ght soils are best adapted to the cork oak, and it will not thrive on
ow or heavy adobe soils. Granitic soils seem to suit it specially.

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It should do well in the San Joaquin River region, where such soils prevail, as well as in the foothills. It is naturally of slow growth.

BAMBOOS.

Reports from the bamboos sent out by the University come in slowly, but cover a good deal of territory.

A plant of *Thamnocalamus*, sent to *W. Haddox, El Monte, Los Angeles County*, grew the first year, but died the next from "alkali in the soil." The land was very moist "corn land." Ramie grew upon it with extraordinary vigor.

D. M. Dimmick, Carpenteria, Santa Barbara County, reports: The *Metake* bamboo seems to be the same variety that I have growing under another name, and which does not yet get large enough to make even fish poles. A plant that my neighbor got from Sanders for the "giant bamboo," but which is the same as that grown by other neighbors as "southern cane," seems to be of value, making canes nearly two inches in diameter by twelve to fifteen feet high.

Mr. L. Guss, of Wright's Station, states that the canes of his plant are now nine feet high, on very dry land; no irrigation. The variety is the *Thamnocalamus spathiflorus*. It was not affected by the winter, nor did it blight in the summer heats.

F. Spangenberg, of Cupertino, Santa Clara County, writes: "The *Metake* bamboo was received in February, and put out the first year four shoots four feet long and one fourth of an inch in diameter. The second year, 1888, it sent up four shoots six feet and three eighths of an inch in diameter. It is now an immense clump or group of stems. The *Ringal* bamboo, received in 1888, appears more vigorous than the *Metake*. The soil is a good sediment, but not irrigated.

Mr. R. Butcher, of Santa Clara, planted the *Metake* bamboo, and the canes are ten or twelve feet high, vigorous and healthy. It received the same irrigation that the roses and shrubs did. It "spread underground" so fast "as to become a nuisance." He uses the canes for supports for small plants. Otherwise the value of the bamboo appears to him "purely ornamental."

The most complete report received was written by *George E. Colby, of Claremont, Alameda County;* the variety is the *Arundinaria falcata*. He says: "The height attained this season, 1890, is fourteen to eighteen feet; the diameter of the cane is about one half to three fourths of an inch at the base. The plant was watered two or three times a week till last year; then irrigation lessened one half. It is planted in the lawn; soil for space of two feet around plant kept well and is deeply tilled. During the winter of 1887–88, the coldest for many years here, the plant did not appear to suffer in the least; during September, 1889, the 'norther' struck it with full blast, and, aside from whipping off some of the leaves, it was not injured at all. When planted (1886), the canes were about ten in number, of the size of a lead pencil in diameter, and about three and a half to four feet long. At the end of the first season it stood eight to ten feet high, with a solid clump of canes about eighteen inches in diameter. At that time the plant was divided, leaving about one half standing; since then it has grown to its present height, and is over two and a half feet in diameter. The total number of canes grown by this plant since 1886 is one hundred and seventy-five. As an ornamental plant for lawns it certainly can hardly be equaled, and it attracts a great deal of attention."

Full reports of the *Ringal* and *Metake* species come from Robert Haste, of Clayton, Contra Costa County; from E. D. Wheatley, of Delano (whose plants died; alkali soil); from A. Keith, of Riverside; H. B. Gaylord, of Auburn; A. B. Harrison, of Danville; and E. W. Harrold, of Saticoy. These kinds seem to have done better, as a rule, than the Indian species, the *Thamnocalamus*.

Arundinaria falcata, sent to George Harvey, of Forestville, grew eight feet high the third year, with canes one inch in diameter. It was perfectly hardy. Another variety showed canes fourteen feet high "on shallow soil." He uses this bamboo to some extent for fencing. He makes the suggestion that bamboos planted along watercourses would be much better than willows—more free from insects, and far more useful when established.

Mr. Charles Knust, of Cloverdale, reports failure through cold and drought, he thinks. "The soil," he says, "is too dry and gravelly." Guavas sent to him are thriving.

Mr. W. Still, of Sonoma, tested the *Thamnocalamus*, and he also reports failure, both with plants from the University and with an importation from Honolulu. He advises larger plants sent out later in the season, after frosts.

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. Reed, Chico, Butte County, says: "I think there is no question as to the bamboo's bility to this climate, as each lot has done finely. They took root at once and t quite a number of shoots from two to four feet high during the summer. All it here is plenty of water. I have three other varieties, all doing finely.

THE MULBERRY.

s likely that some of the best species and varieties of the mulberry wn in this State, many of them introduced by the University, will e leading avenue trees. The value of the mulberry for shade, for or home use, for timber, ultimately for silkworm culture, and its ne ease of culture, make it desirable that people should know about the tree. It thrives on widely different kinds of soil, and the stations. The trees on the University grounds are very tive specimens; plants and cuttings have been sent to all parts of ate.

following memoranda from various growers will serve to illus- he widespread success of the tree:

rick Allbright, of Estrella, San Luis Obispo County.—I have saved three out of the uttings sent me, and the trees are from ten inches to one and a half feet high, finely. I irrigated once every week or two, by removing the surface, watering lly, and then replacing the earth. Some Russian mulberry trees (received from) started quite slowly, and the heat and dryness were pretty hard on them for a ut at length they started and are growing through the hottest weather, as though ia *adobe* were their native soil. I take it, that the Russian mulberry will be very e to set out for posts for our wire fences; the *Nagasaki* is the best.

e Weiss, Creston, San Luis Obispo County.—The cuttings (Russian, Alba, and Naga- iled to take root, though I watered them frequently. The Russian mulberries e before, start to grow too early and are caught by the late frosts. The New an mulberry is much better. It has made a growth of eleven feet in two years e bud, and has borne fruit for me since 1888.

ip, Arroyo Grande, San Luis Obispo County.—In the spring of 1887 I received from versity six varieties of mulberry cuttings. Several failed to start; some started n died. The gophers ate most of the rest; only one is living now. This one got rosted in January, 1888, the ends of the branches being wilted, and a gopher ate ll the roots off. I replanted it, and it is making a fair growth. A neighbor has lberry tree which has grown well and is beautiful.

Maxwell, San Miguel, San Luis Obispo County.—Four varieties of mulberry (Down- ssian, Alba, and Nagasaki) made a fine, bright, and vigorous growth from cut- lanted in sandy loam and transplanted January, 1888. They are now, in 1890, ees.

Lanigan, San Ardo, Monterey County.—The mulberry cuttings budded and formed es, but afterwards perished with the dry summer season.

Roache, Watsonville, Santa Cruz County.—The mulberry cuttings failed to strike They budded, leaved, and the young shoots attained four or five inches in length, uddenly they began to wilt, and they died in spite of my efforts.

t G. Adair, Alma, Santa Clara County.—The Japanese mulberries are doing splen- 50 per cent of the cuttings grew.

Reynolds, Kelseyville, Lake County.—The Downing mulberry cuttings were budded hite mulberry stocks, and have made a heavy growth. The New American on ite, by buds, has done exceedingly well. Buds put in last spring are seven feet None have fruited yet, but this is evidently the home of the mulberry.

he many species of the mulberry, *Morus alba, M. nigra, M. mul- is, M. rubra, and M. japonica*, with their sub-varieties, are best ed to the greater part of the State, including the interior, where ival the fig in enduring heat, even where only a moderate supply isture is to be had. At the station in Amador, and that at Paso s, they have grown better than any other tree. The hot weather last two summers affected their foliage but slightly. The best rs, and the handsomest trees of the group, have proved to be the ese *Nagasaki* and *Lhoo*, which also have a large leaf of close e, admirably adapted for the food of the silkworm. First, let erries be planted along our roadsides until the tree is as common

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and familiar a sight as the willow. Then, with more abundant labor and the development of the Old World industries, silk culture will take its place among the profitable occupations of California.

The Japanese varieties just named undoubtedly take the highest rank of all the known sorts for general planting in California. In three or four years a farmer can get shade and shelter about his house and outbuildings by using these large-leaved and fast-growing mulberries. The White has much smaller leaves and gives much less shelter.

NEW ZEALAND FLAX.

The astonishing strength of the raw fiber of the New Zealand flax (*Phormium tenax*) makes the plants valuable for every gardener and farmer, who can use strips of the leaves for many purposes. A distribution of this plant was made several years ago, and sufficient time has elapsed to bring in some reports, from which the following notes are selected as typical of all:

Mrs. L. S. Cleland, Mesa Grande, San Diego County.—Not knowing its nature or habits, I planted the New Zealand flax seed in a very sunny exposure, and the young plants were burned off in a single hot day.

P. S. Russell, San Jacinto, San Diego County.—The New Zealand flax started to grow in the spring, but as the hot weather approached it all died.

John Wandall, Hollister, San Benito County.—The New Zealand flax is doing well.

S. Slocombe, Cayucos, San Luis Obispo County.—The *Phormium tenax* died; the soil and climate, I believe, are too dry for it.

Wm. Quentel, Pacific Grove, Monterey County.—The New Zealand flax grows well, and is both ornamental and useful.

G. Rothermal, San José, Santa Clara County.—The cold of January (1888) did not hurt New Zealand flax. Its growth is luxuriant.

F. Spangenberg, Cupertino, Santa Clara County.—Although my New Zealand flax is not as thrifty as reported from Santa Cruz, still it is vigorous and useful enough to pay for all the attention given it. It grew three feet in moist sediment, although removed and replanted under unfavorable circumstances.

G. P. Rixford, San Francisco.—The New Zealand flax seems to prove successful everywhere except in very dry locations, where it will require some irrigation. We find it exceedingly valuable on the ranch (in Sonoma County) for tieing purposes; the fiber is so strong that it is useful for tieing up vines, trees, sacks, or any other purpose for which tieing material is used.

Alex. Manning, San Rafael, Marin County.—The New Zealand flax was doing nicely until a neighbor's cow entered and tore it from the ground.

Wm. H. Hilton, Glen Ellen, Sonoma County.—The New Zealand flax continues to do well. Last winter we had unusually cold, frosty weather, but it did not affect the plants. They are set in clayey loam, and require watering.

A. Requa, Cahto, Mendocino County.—The New Zealand flax grows well in my flower beds.

James Hodge, Hanson, Humboldt County.—The New Zealand flax makes a rapid growth, and has very strong fibers. It is very handy for tieing purposes.

E. W. Maslin, Pino, Placer County.—I have planted the New Zealand flax twice. It seems to flourish so long as the spring is cool, but upon the first heats of summer it gradually dies down to the bulb, which, upon examining, I found dead. This is on unirrigated granitic soil.

Isaac Lea, Florin, Sacramento County.—The New Zealand flax will not grow here without irrigation.

C. Brower, Bakersfield, Kern County.—One of the New Zealand flax plants was planted in moist bottom land; others in sandy loam slightly more elevated. Those on the sandy land, though moderately irrigated, failed to survive the summer (1886); that on the low land appeared to suffer from the dry heat of summer, and it has never made a vigorous growth, though still living and slowly increasing in size and apparent health. It is now about three feet high, and some twelve inches in diameter at the ground; is apparently not adapted to the dry heat of our interior valleys, and in point of ornament is far inferior to the pampas grass.

The New Zealand flax, as shown by the above reports, is not adapted to many locations removed from the seacoast. It does not thrive in too hot districts, nor on the driest soils. But it needs drainage; the roots must not reach bottom-water. Moderately moist soils suit the

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best. It is not a swamp plant, as many seem to think, but does in good garden soil, well cultivated.

THE MELON TREE.

e true place of the melon tree (*Carica papaya*) is pretty well estab-d in California horticulture. It is only a few climates, such as that ontecito, Santa Barbara County, and southward, that have the test chance of success with this tender plant. Report has been before now of the thriftiness of the *Carica papaya* in San Diego ty. Some Los Angeles, Ventura, and San Bernardino locations, ome limited areas of the Sierra foothills, might possibly come up to ery satisfactory report from Montecito.

. Beckwith, Los Gatos, Santa Clara County.—The melon tree, I think, is worthless In the hot summer weather the flowers blast or drop off, and the fruit only sets fall in cool weather, and then does not get ripe before rain and cold spoils the I am in doubt if the fruit is of any value when you do get it, though the plant is ornamental.

Chappelow, Duarte, Los Angeles County.—Two melon trees were sent, but both have rom what cause, I know not. They were planted in sandy soil.

. Dimmick, Carpenteria, Santa Barbara County.—The melon trees did not get frosted, emed to chill, and then died.

n Stevens, Montecito, Santa Barbara County.—The two melon trees have made a fine . I think so much of them that I procured seed from China, and have about undred fine plants. I feel sure, that with a little care while young, it will succeed with us in Montecito as the *Anona cherimoya*, the alligator pear, and the mango, do well, producing and perfecting their fruit.

y F. Speetzen, Watsonville, Santa Cruz County.—The melon trees never showed any life after I planted them in the open air on a sheltered spot.

Sheldon, San Buenaventura, Ventura County.—The melon trees died. I have a very ble location, and I think they were killed by the cold in coming, for they com-d to decay at the top of the ground almost immediately; it did not seem to be a , but they turned black, and became slippery.

k Dana, Nipomo, San Luis Obispo County.—The melon trees were killed by a gopher. ell of the tree seemed to attract the gophers, as both trees were killed by the same although they were twenty feet apart.

t Hansen, Anaheim, Los Angeles County.—A stray cow destroyed the melon trees.

ith, Riverside, San Bernardino County.—The melon trees both died. The cause was torm soon after setting them out. I think they must be extremely tender.

am Pfeffer, Gubserville, Santa Clara County.—Owing to ignorance on my part about g such plants as melon trees, I found them, four days after planting, dried up (on hillside).

as Spencer, Anaheim, Los Angeles County.—I regret to state that the melon trees abed to the extraordinary weather of January 16th, when the thermometer regis-3 degrees. I nursed them carefully, but they soon began to rot, and then died.

OTHER DISTRIBUTIONS.

avas.—Several reports have been received about the guavas sent 1884. C. O. Tucker, of Ballena, San Diego County, writes that his experience he "has formed a very high estimate of the value e tree for this locality."

fee.—It is often said, by those who have not taken pains to ascer-he facts, that large coffee plantations will certainly be seen in Cali-some of these days. The place for a commercial success in this e has not yet been discovered. Witness the following: Mr. A. , Riverside, writes as follows: "Six coffee plants were received the University about 1884. I took a great deal of pains with them, he last one died in 1888. I do not believe that they can be made ow out of doors in this climate." Mr. B. J. Rice, Fallbrook, San County, reports a similar experience.

e *Catalpa* was sent out to all parts of the State, and did very well,

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particularly in San Luis Obispo, Santa Clara, Alameda, and Sonoma Counties. M. C. Woodson, of Nuevo, San Diego County, writes: "I have one thousand *Catalpa speciosa* on high, dry mesa land that have made a growth of from four to seven feet this year. I think the catalpa is the most desirable and most profitable timber to grow.

The *Strawberry Tree* (*Arbutus unedo*) appears to have done fairly well in most counties of the State. Reports show that it has lived and grown, though slowly, in San Luis Obispo, Calaveras, Mendocino, Los Angeles, Santa Clara, Humboldt, Monterey, Sonoma, Colusa, and Tehama Counties. It does better near the coast; the hot, dry climate of the interior valleys appears to check its growth. At Fresno, where the thermometer registered 114 degrees Fahrenheit the season reported, the tree did very poorly. Nevertheless, a tree in Inyo, where the heat was probably greater, appears to have succeeded. The tree responds quickly to irrigation.

Of the various *Maples* that are native of the country east of the Sierras, none except the *Acer negundo*, or "box elder," has ever equaled our native California species. The most valuable of the native species is the *Acer macrophylla*, which, in suitable soil and within the range of the moist ocean winds, is of enduring and rapid growth. It can be highly recommended as an avenue and shade tree. The timber, also, is quite valuable.

PLANTS ALONG NORTH STRAWBERRY CREEK.

By Charles H. Shinn.

No portion of the University grounds is more interesting to a botanist than the narrow, winding border planted with shrubs, vines, and trees, and extending along the north bank of North Strawberry Creek. This border begins near the greenhouses and continues west, with a few breaks, past the nurseries, the seedhouse, orchard, and new grape plantation, and across the Economic Garden. The most attractive portion is in this latter division, extending west to the boundary of the University grounds.

Native shrubs and trees, left standing when the ground was broken for the garden, mingle with the exotics. Close by the greenhouses the cutting of trees that overshadowed the beds has given some interesting plants a better chance for growth; one of these, *Brugmansia sanguinea*, is one of the most attractive semi-tropic shrubs for ornamental planting. Its funnel-shaped flowers of yellow and pale scarlet are eight or nine inches long and three inches across. As if to mark with special emphasis the climatic contrasts, a fine *Sequoia sempervirens* (redwood) and a deciduous cypress of the South stand near this semi-tropic datura.

Passing between two large live oaks, beneath whose shade several Japanese camellias are growing vigorously, the cordon walk of pear, apple, and cherry is the next feature, but this has been amply described in previous reports. The pears and apples have almost no crop this year; the cherries (Governor Wood) bore a fair crop.

West of the cordon walk several good specimens of English oaks stand near the bank. Adjacent to them is an oak nursery, in which five or six species stand, with a few specimens of the *Chionanthus Virginica*, or Fringe tree. The wild-plant garden extends north from here.

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Crossing a path the mulberry plantation is reached. *M. multicaulis*, *M. alba*, Downing's ever-bearing, the Russian, the Japanese, and the Chinese are represented here; the Japan species (Nagasaki and Lhoo) are the strongest growers, while the Russian seems comparatively poor. Several healthy specimens of the Japanese mammoth chestnut are here; they have a remarkably low and spreading habit, in this soil, at least, a habit quite unlike that of any other chestnuts, and different from that of the same species in some other localities. A tree of the European *Diospyros*, or persimmon (*D. lotus*), on the bank of the stream, is beginning to bear fruit.

Passing the seed-house, built across the channel of the creek, the orchard comes close to the bank, and there is only room for a few things, chief among which are mountain ashes (*Sorbus Aucuparia* and *S. Americana*), and several of the best species of *Cratægus*. All of these are particularly ornamental in winter. A specimen of hickory (*Carya alba*) is at last beginning to make a fair growth. A large tree of the *Hovenia dulcis*, a highly recommended fruit-bearing tree from Japan, has proved a disappointment so far, not yet showing any signs of blossoming. There are specimen trees of wild crabs along the creek here, and places where plums and other native American fruits can be planted. The western apex of the triangle, between the bend of the creek at this point and the roadway, is marked by an olive tree, and south of the creek by the beginning of the eucalyptus grove. This grove once extended north of the creek, but in the autumn of 1890 a portion of the land was cleared, and a collection of different species of grapes was planted last spring. The space occupied is properly a part of the extended creek border.

The creek border in the Economic Garden covers a much greater variety of plant-life than any other part of the strip of territory under consideration. A few rods of the narrow border here would interest any botanist. A finer illustration of what California gardeners can easily do with the broken slopes of ravines could hardly be found. Live oaks, buckeyes, and laurels grow on the banks, and vines of wild pea and blackberry clamber over them. The pomegranates, oranges, bamboos, and plants to be hereafter noted, have become established in the midst of such native specimens.

One of the finest trees here is a large camphor, which thrives wonderfully. A *Salisburia adiantifolia* is close to the camphor; also, a large specimen of *Rhus Coriaria*, the true tanner's sumac. Thorny *Acacia Greggi*, and other Arizonian plants of the desert, grow, though not rapidly, and the *Agave Americana* is perfectly at home. A carob tree (*Ceratonia siliqua*) stands fully twelve feet high, and quite that much in width. The useful and interesting honey mesquite of the Southwest (*Prosopis juliflora*) is represented by a healthy, though small, plant. A superb specimen of *Ruitzia fragrans*, a Chilean tree, and several other very handsome Chilean species, are worthy of especial notice. *Pistacia terebinthus* and *P. vera* grow near each other, sheltered by native oaks. A plant of the thorny *Aberia Caffra*, or "kai apple" of South Africa, seems to thrive, though increasing in size but slowly; this plant suffers from the slightest frost, and is less hardy than the lemon.

Close to the bank of the stream, but separated by a narrow path lined by violets, is a large vine of the curious *Pueraria Japonica* supported upon a trellis. This is the "starch" vine of Japan, and its handsome flowers and rapid growth make it worthy of ornamental use, while its

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large tubers are said to be valuable for food. Other plants of the immense leguminous class are to be seen in the vicinity—the superb *Edwardsias*, *E. grandiflora* and *E. microphylla;* the *Virgilia lutea*, *Cercis occidentalis*, several species of *Cytisus*, and a wall of acacias, twenty-three species of which are grown in the experiment grounds. A charming little tree of graceful foliage is the *Sophora Japonica*, extensively cultivated as a dye-wood.

The narrow border shows several of the *Araliaceæ*, such as *A. spinosa*, the Hercules club; the odd "rice-paper" tree, *Fatsia papyrifera;* and a number of ivies. There are wild gooseberries and currants, *Ribes sanguineum* and *R. Menziesii* being most important, both of these native species left growing with blackberries, honeysuckles, oaks, and willows.

Among the rarer plants now of considerable size, and showing adaptation to the locality, are two *Cinnamonums*, *C. glaucum* and *C. sericum;* the slow-growing *Macadamia ternata*, or Queensland nut-tree; the stiff-leaved, brilliant-flowered *Hakea acicularis*; the "tallow-tree," *Stillingia sebifera;* and the *Cinchona officinalis*, which sometimes needs a little winter protection. *Psidium Cattleyanum*, the purple or strawberry guava, forms a large bush, untouched as yet by frost. *Thea bohea*, the Chinese tea plant, grows fairly well. The Argan tree of Barbary (*Argania sideroxylon*), the stiff-leaved *Berberis Japonica*, with greenish-red berries, and the purple-leaved hazel, grow near the guava, tea, camphor, and cinchona plants.

A few hundred feet from the stream many other plants of interest are found, and the range of species is greatly increased. But it was stated at the outset that this was to be merely a glimpse of the part of the experiment grounds that lies along the brook, from the greenhouses west to the University boundary. Many of the species represented here have not been mentioned, but the range of climate is perhaps sufficiently indicated.

THE WEEDS OF CALIFORNIA.*

By E. W. Hilgard.

It has ceased to be usual to begin a history with the account of the creation; and even thus, it might be unnecessary to begin a treatise on weeds with a definition of the meaning of the word, were it not that common usage attaches to it two really distinct ideas, having in common only that of a hardy plant that is of no particular use. But to one class attaches the reproach of being a persistent invader of the husbandman's realm, difficult to repel; while another consists simply of hardy plants, thriving under difficulties which discourage more useful growths, and therefore obtruding their presence on roadsides and other waste places. It will hardly do to go so far as to attach the opprobrious term to *any* plant that habitually appears in a place where it is not wanted, despite the analogy of the "dirt" on the goldsmith's apron, and the "pay dirt" of the placer miner.

It has not uncommonly been noted, as a matter of surprise, that the troublesome weeds of any country are rarely aborigines thereof. In reality this is probably but one of the phases of the survival of the fittest

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under *natural* conditions, for neither roadsides and waste places on the one hand, nor cultivated ground on the other, can be placed in the latter category. In order to become a weed, a plant must be placed under *unnaturally* favorable conditions, unlike those which have naturally concurred toward the secular co-adaptation of plants, soils, and climates. We see the converse process in the complete disappearance of native plants that have formed the predominant growth, as, *e. g.*, that of the buffalo grass (*Buchlöe*) from the plains of Nebraska and Colorado, not as the result of displacement, but of unsuitable conditions; while the thistle on the pampas, and the guava on the Hawaiian group, are examples of almost complete displacement of native growth by foreign invaders.

In California the progress of the invasion by some of the most common weeds can be currently traced as yet in the more remote regions, and the influence of climate in modifying the "weed nature" of a number of well known plants forms an interesting study.

The broad fact in the premises that first strikes the newcomer in California is that a number of plants that are the subjects of careful culture east of the Rocky Mountains, as well as in Europe, and which quickly succumb when deprived of artificial protection there, are here found among the most persistent and obnoxious weeds; while very many of those that are specially abundant and troublesome in the Atlantic region, are conspicuously absent on the Pacific side. Foremost among the former class are the two "mustards," *Brassica rapa* and *nigra*, respectively known as "white mustard" (or "wild turnip") and "black mustard;" and next to these, the common radish (*Raphanus sativus*—not *R. raphanistrum*, of the European fields). The first named is most abundant on the borders of the bay of San Francisco, and occupies not only abandoned fields, but disputes the ground with the cereals to such an extent that it is often difficult to believe that it has not been planted on purpose; and were rape-seed oil as much sought after as of yore, California could doubtless "beat the world" in growing its parent plant.

The black mustard is of more extended prevalence, and both in the coast region and in the Great Valley takes possession of neglected fields to the exclusion of everything else, growing so tall in rich soils as to hide horse and rider, and forming impenetrable thickets that, like the thistle of the pampas, serve as a place of refuge for wild animals. In the Santa Barbara region such mustard patches are often cut for their seed, which is extremely pungent; but the crop often fails, in consequence of the overwhelming attacks of an aphidian upon the peduncles and forming pods. Apart from this latter drawback, California could also probably defy competition in mustard culture.

The radish is not quite so overwhelming in its attacks upon cultivated ground, but large patches of its rose-colored flowers often contrast very prettily with the prevailing yellow of the two *Brassicas;* and the extirpation of its roots, equally tenacious in texture and life, and enduring several years, is no small problem in badly infested fields. Its habit would seem to indicate its derivation from some one of the "long" varieties of the cultivated plant.

Of other cruciferous weeds, the hedge mustard (*Erysimum officinale*) is somewhat troublesome at times; the shepherd's purse (*Capsella*) is well acclimated but hardly obnoxious. Of native crucifers, the only one that maintains its place among cultivated crops with some tenacity

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is the *Tropidocarpum gracile*, which finds improved conditions of existence in the irrigated districts of the upper San Joaquin Valley.

Of other cultivated plants that maintain themselves by roadsides and elsewhere in the open country in suitable ground, the *celery*, *carrot*, and *fennel* are conspicuous. The tall and dense bushes formed by the latter, even on well-trodden roadsides, recall the mention of fennel thickets, dreaded as the lurking places of wild beasts by travelers, in the coast region of Asia Minor. The Fuller's teasel, likewise, has escaped from cultivation, and forms a serious pest at some points.

Of weeds conspicuous on the Atlantic side and almost unknown as such in California, the entire series of *Polygonums* is perhaps the most striking example, excepting only the *P. aviculare*, the knot-weed or bird-grass, which is probably more troublesome here than anywhere else, the rainless summers being nowise against its full enjoyment of life, and in the prevailing absence of summer cultivation, enabling it to develop into gigantic wheel-shaped specimens, as much superior in size to their eastern brethren as are the proverbial California pumpkins. It is, however, a more or less acceptable pasture plant for cattle during the dry season. By ditches and in meadows a few scattering plants of *Polygonum lapathifolium*, *Pennsylvanicum*, and a few others are occasionally seen; but they do not maintain themselves and do not spread into the cultivated fields.

Of their near relatives, the *docks*, however, there are several that count among the more troublesome invaders. While *Rumex sanguineus* and *obtusifolius* are hardly more often seen than are the *Polygonums*, three others—*R. crispus*, *pulcher*, and *acetosella*—are common and extremely tenacious of life, sprouting up from their roots, cut by the last cultivation in May, at any time during the dry season, and seeding quickly and abundantly.

Of *Amaranths* it may in general be said that they flourish in the fields of California as well, or even better, than on the Atlantic side, although somewhat changed in habit. The *A. retroflexus*, as troublesome in California vineyards as among the corn and potatoes of the Prairie States, forms here mostly a flat, wheel-shaped mass, from which the ground squirrel, stooping down, gathers its winter hoard. The *A. albus* (white pig-weed) maintains very nearly its eastern aspect.

Of *Chenopodiums*, *Ch. album* and *bonus Henricus* are almost, if not quite, as familiar as in the East and in Europe; *Ch. vulvaria* likewise is found, but less generally diffused.

Portulacca oleracea, so common and troublesome in Eastern and European gardens and fields, has appeared in a few localities, but although doing well, has made no headway as a troublesome weed. The altered aspect of its fleshy leaves, which become much reduced in size and almost terete under conditions of extreme drought, so that the thick red stems resemble a group of stout radially-disposed worms, suggests a marked adaptation to environments.

The native *Claytonia perfoliata*, although somewhat persistent among the grass in moister ground in spring, hardly maintains itself against regular cultivation. But its pretty relative, the *Calandrinia Menziesii*, does not give up so readily and may be seen covering the ground in orchards and vineyards in the coast region, forming a beautiful carpet of purple that attracts attention from afar. Its vegetative duration is too short and its root system too light to render it troublesome; but the multitude of its shining black seeds render it difficult of extirpation.

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Premising the above as a preliminary sketch of "the situation" in California in the matter of weeds, I shall discuss the remainder under their respective orders, in the usual sequence.

Of the *Caryophyllaceæ*, the most universally diffused and quite troublesome member is *Silene gallica*, which seems to be able to withstand the most severe aridity attained in the lowlands of California; at least, in the central portions of the State.

Stellaria media (chickweed) is among the most persistent of summer weeds in cultivated vineyards and orchards; while in the spring *Spergula arvensis* (spurry) takes possession of the moister grounds in the coast ranges, as well as in the Great Valley.

Mollugo verticillata is seen sporadically, but is not as troublesome as in Eastern corn fields.

Of the *Papaveraceæ*, the *Eschscholtzia Californica* maintains itself somewhat tenaciously in pastures, but hardly in regularly cultivated ground. Yet in grain fields, where its spring bloom has been prevented by cultivation, it will very commonly recoup itself by a copious autumn florition, the seeds of which serve to restock the ground promptly and thickly. Thus it forms large areas of flaming orange on the outskirts of growing towns, where the ground has ceased to be cultivated with regularity.

Of the *Malvaceæ*, almost the only member that is really a weed is the *Malva parviflora*, although a few others are locally complained of. This is the "Malva" par excellence, regarding the extirpation of which many newspaper articles are written without reaching any very definite conclusions with regard to its repression on ground favorable to it. It is at home in the heavy black clay or "adobe" soils of the Coast Range, where it will grow to four and five feet in height under favorable conditions, but on roads will form decumbent wheel-like masses resembling those of its Eastern congener, the *M. rotundifolia*. Its seeds, borne in the greatest profusion, will germinate with the most surprising readiness, even when the plant is killed quite green; the seedlings will be found coming to the surface from the depths of the soil-cracks in midsummer, and mature an abundance of seed under the most discouraging conditions. It is one of the most persistent weeds the California farmer has to combat, and its extirpation from ground once well stocked with it seems almost hopeless. Some have recommended it as a forage plant, but few cows will touch it so long as anything else is in sight.

The *Geraniaceæ* are prominently represented by the *Erodium cicutarium* and *E. moschatum*, both commonly known as alfilerilla or alfileria, and both widely diffused. The first named is, however, not only the one that has been carried even to the remotest districts of the State, but is distinctively the species possessing the value as a forage plant, which is sometimes erroneously assigned to both. For the *E. moschatum* is so distinctly of musky flavor, that, like the *Anthoxanthum* among the grasses, it is eaten only in limited quantity by any animal as a flavoring; an alfilerilla pasture once overrun with the musky species ceases to have much value, while in heavy, rich soils the more valuable kind is often completely "run out" by the other. In light, sandy soils the *E. cicutarium* is more likely to hold its own. Its long red tap-root will descend for moisture to the depth of several feet, and will keep green when everything else that is of value as forage is dried up. The rosettes formed by its radical leaves lie close to the ground in winter

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and resist even heavy frosts without injury. Both plants are regarded as marks of a rich soil; and in such soils the task of keeping them in check is indeed a serious one. For the seed will continue to germinate in the driest and hottest times of midsummer, after the land is "laid by;" and the costly operation of hoeing alone can master it at that season. The propagation of the alfilerilla as a pasture plant is rendered difficult by the nature of the seeds with their long, spirally-coiled awns (styles); and in certain sandy soils of South California its spread is arrested by the red ant, which gathers the seeds in its burrows, leaving conspicuous piles of the awns outside around the hills.

Of other *Geraniaceæ*, the *G. Carolinianum* is the only one that occasionally appears as a weed, but it is easily conquered.

Oxalis corniculata is locally a very persistent weed, resisting the summer's drought to an extraordinary degree; but it is not generally distributed, though more common in Southern than in Northern California. No other "sheep sorrels" have reached the State.

The western poison "oak," or rather sumac (*Rhus diversiloba*), is a very persistent invader of pastures on which it formed part of the original growth, and keeps sprouting up from fragments of rootstocks remaining in the soil, for years. In company with the brake fern (*Pteris aquilina*) it is usually the last of the native vegetation to be subdued by cultivation, both in the coast ranges and in the foothills of the Sierra Nevada.

Of the great *Leguminous* family, only four members can be said to be generally obnoxious to farmers, viz.: the burr clover (*Medicago denticulata*), the sweet clover (*Melilotus Indica*), the sand lupin (*L. formosus*, Greene), and the native licorice (*Glycyrrhiza lepidota*). It is true that some of the many native clovers, though mostly annual, persist for a while among the grain; but they soon disappear from cultivated fields and only remain in pasture grounds, where they are all welcome.

But the burr clover, apparently one of the earliest European introductions, is of a very different temper. Although an annual, its long, wiry, deep-going roots enable it to survive repeated croppings, even unto another season. Under the influence of somewhat generous spring rains, its usually decumbent stems will become assurgent and clothed with luxuriant foliage, forming a heavy, dense mat on the ground, six to ten inches thick, and apparently a most inviting pasture. But its inherent bitter taste prevents any serious damage being done to it by pasturing cattle, which pick the early grasses in preference. Thus the clover is allowed to mature its coiled pods, armed with hooked bristles, and borne in such abundance that they often form a layer over an inch high where the plant, after the cessation of rains, has disappeared before the summer "northers," only a few wiry stems remaining. These burrs form a highly important ingredient of the "dry pasture" in the coast ranges, where cattle get fat on ground that looks, to the newcomer, as barren as burnt prairie on the plains. Sheep, of course, also thrive on the pods; but the damage done to the value of their fleece by the inextricable burrs is so great that burr clover pastures are sedulously avoided by the sheep men.

But during the summer drought this plant changes its nature to suit the altered conditions, and where the ground is cultivated the seed of the same season soon germinates and a second crop comes up to worry the cultivator. It does not take the insidious little plant long to develop

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into wheel-shaped mats of all sizes, lying flat on the ground, with minute leaves only, and soon covering themselves with closely packed burrs in great profusion. At this time the stems are wiry and tough, and only a very sharp hoe will cut either root or stem. But the seeds acquire germinating power so quickly, that unless eternal vigilance is exercised, a close mat of young plants will be found in spring where an apparently wretchedly depauperated specimen seemed hardly to maintain life the previous summer. It appears as though the burr clover had found in California conditions more favorable than anywhere else in the world.

The yellow melilot, also, appears to find a most congenial home in all the richer soils, where moisture is not too deficient. Thus, it grows not only on the banks of brooks and ditches in the coast ranges, as well as in the Great Valley, but is also found on the roadsides and in the cereal fields, completing its growth and fruiting, like the latter, in the spring or early summer. Hence, when the cereals are cut for hay, the melilot often goes in as a flavoring ingredient, to an extent which renders the hay distasteful to horses, at least. Worse than this, it is harvested with the grain, and, if left even in the sheaf for any length of time, so flavors the grain that the flour made therefrom has a distinct "gingerbread" flavor, that is strenuously objected to by millers, both here and in England, and has caused serious discounts upon many a cargo of wheat. Where this plant is mixed with the grain, it is very important that the reaping, thrashing, and winnowing operations should follow each other as quickly as possible; as in practice is done by the "combined harvester and thrasher." Even then, if any considerable amount of the seed is left with the grain, the gingerbread flavor will gradually communicate itself to the wheat grain, and through it to the flour.

The sand lupin is naturally at home on deep, sandy soils, both in the coast ranges and in the Great Valley of California. In these it extends its long, tough rootstocks in all directions, and sometimes forms a matwork of roots that renders it difficult to keep the plow in the ground. As even short pieces of these will root, this lupin—one of the handsomest of its tribe—is a very unwelcome denizen and difficult to extirpate. Its assurgent stems form large, low bushes, brilliant with purple flowers, and will shade out every seedling within its reach. In heavier soils it is much more easily dealt with.

The native licorice shares with the lupin, as with its Asiatic relative, the possession of long subterranean stems, of which even short pieces will sprout into independent plants. It is especially troublesome in the lighter alluvial soils, in which it finds sufficient moisture throughout the season, and which are its natural habitat. But it gathers fresh strength under cultivation, and if not summarily dealt with when the land is first broken, will be much more difficult to eradicate after the fragments of its rootstocks have been further disseminated by the plow. Fortunately it is not as common in California as it is in some parts of Oregon and Washington, where it is known as "Buffalo brush," and covers large areas almost exclusively.

The *Rosaceæ* furnish no plant that could properly be classed as a weed in California, save perhaps that the *Chamæbatia foliolosa*, the procumbent "tar-weed" of the Sierra foothills, sometimes persists for some years after the land it covered has been taken into cultivation.

Of the *Onagrariaceæ*, *Oenothera ovata*, the stemless evening (here more

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properly "morning") primrose, is somewhat persistent in pastures, and if not suppressed will gradually shade out the grasses with its dense rosettes of leaves. It plays the same part that the several plantains do in grass lawns; but its beautiful and abundant flowers plead for its toleration, as do those of the dandelion in Europe and the East. *Epilobium paniculatum* locally invades the moister fields, but is not very persistent.

Of the *Cucurbitaceæ*, two species of *Megarrhiza* (*vulgo* "big root"), occurring both in woods and open grounds in the coast ranges, retain their hold on cultivated lands, as well as pastures, for a number of years, owing to the enormous tubers which, lying from two to four feet below the surface, can be reached only by laborious digging. Persistent cutting-off of the shoots will gradually exhaust the tuber, but if allowed to grow even a short time during each season, it will continue to send forth its succulent climbing runners almost indefinitely.

The *Cucurbita fœtida* (*C. perennis*, Gray), the calabazita of the Mexicans, is common in open grounds in the southern half of the State, and retains a place in the fields with some tenacity, on account of the multitude of its gourds, and the protection their hard rind affords to the seeds. It covers the ground in wheel-shaped masses, eight to twelve feet across, and of course is a very unwelcome visitor in all cultivated grounds. But by cutting off the (perennial) root-crown, and picking up the gourds for a season or two, it can be readily extirpated.

None of the numerous native species of the *Cactaceæ* trouble the husbandman after they have once been removed from the ground; but the latter task is certainly one of the least agreeable. Ordinarily the fleshy stems are left to die and dry up in piles, which are fired as soon as it can be done effectively.

Of the large and copiously represented family of the *Umbelliferæ*, scarcely one can count as a seriously obnoxious weed. The fennel, heretofore mentioned, is a hardy roadside weed, but is easily dealt with in cultivation. The caraway makes no headway; the anise and coriander retain a place in fence corners, but do not spread. The celery seems to have escaped from cultivation into wet grounds, and sometimes covers them thickly, but quickly yields before culture. The carrot is abroad in woodlands and pastures, but is not troublesome. Of the numerous native species, *Sanicula Menziesii* and *bipinnatifida* are apt to maintain themselves in pastures for some time, as do certain species of *Peucedanum* and *Caucalis*, as well as the large *Heracleum lanatum*. But none of these can be accounted serious pests in cultivated ground.

Of the *Rubiaceæ*, the native *Galiums* are quite innocent of harm. *Diodia*, so troublesome in the Cotton States, is occasionally seen, but makes no headway. The *Rubia tinctorum*, however, spreads energetically in heavy soils, and would doubtless prove a serious pest were it to escape from cultivation.

Of the *Dipsaceæ*, as stated above, the Fuller's teasel has become a common roadside weed in the Bay region, and runs riot in waste grounds; it could doubtless be cultivated to great advantage in this genial climate, could a market be found for it. The garden Scabious, also, has escaped, and frequently occupies the ground on dusty roadsides.

The *Composite* family furnishes some of the most obnoxious and interesting weeds, and a considerable number. Broadly speaking, there are six chief introduced species that give serious trouble, to wit: First, and worst

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of all, the *Centaurea Melitensis* and *solstitialis*, introduced from Southern Europe, and almost universally diffused under a variety of names; second, the *Cotula vulgaris*, a comparatively recent arrival; third, the *Silbyum marianum;* fourth and fifth, the two cockle-burs, *Xanthium strumarium* and *spinosum*. To these may be added as of less importance, although likewise widely diffused, the *Senecio vulgaris*, *Sonchus oleraceus*, and *Erigeron Canadense*. All of these well known weeds may be seen at their best in the fields and pastures of California, but little changed from their Eastern or European habits, but exhibiting a resistance to heat and drought that would hardly have been looked for in their native climes. Alongside of these foreign invaders, a few native composites play a subordinate and relatively innocuous part.

The two *Centaureas*—the tocalote of the Mexicans, and the Napa thistle and prickly tar-weed of the Americans—deserve more than a passing notice as being, with the black mustard and the "barley grass" (*Hordeum jubatum*), the most formidable weed pest for both fields and pastures, particularly in the central and northern parts of the coast ranges. Starting in early spring, the *Centaurea Melitensis* especially will mature seeds in May; these, or any others, will germinate again under conditions of heat and dryness that will permit no other seed to move; this second generation again runs to seed rapidly, and may in its turn be succeeded by a third, maturing its seed in December. The wiry tap-root, penetrating deep into the soil, requires a sharp tool to cut it. The tocalote is thus a weed that, unlike almost any other within the State, gives the farmer no summer rest where it is once well established. In pastures it is even a worse pest than in cultivated fields, as it will take possession of the ground so soon as even a casual overstocking occurs, being able to avail itself of any chance that may occur throughout the season. It quickly and completely runs out the native grasses, and it is impossible to restore the grass without previous cultivation. For, although the plant is an annual, if cut anywhere above the root-crown, it soon sprouts decumbent branches, that will bloom and fruit under the very tread of cattle; and if again cut, the same process will be repeated the same or the following year. The slender, sharp spines of the involucral scales (quite strong and long in the true *C. solstitialis*) render the plant doubly obnoxious to the pedestrian when dry, while in the green state, the viscous tomentum of stems and leaves soils the clothes. In grain fields it sometimes covers the ground completely after harvest, seeding it thoroughly for the coming season.

The *Cotula* comes next to the tocalote as the enemy of overstocked pastures. It is not yet widely diffused, and has reached the borders of San Francisco Bay within my own recollection—about ten years ago, when I first observed it on the road from Oakland Point to Berkeley. Within two years it reached this place, and then, favored by the trade winds from the west, it quickly ascended the Coast Range, and now disputes precedence with the tocalote, up an elevation of nearly one thousand eight hundred feet. As its vegetation is somewhat earlier than that of the thistle, it shades out the latter during the early part of the season; but later the tocalote takes its turn, and between the two the hill pastures are left in a sorry plight. The "May weed" does not, however, occupy waste places in this region as generally as is the case in the Cotton States; its growth is low, and, as there is only one generation each season, it seems that it might readily be kept in check on cultivated ground, which as yet it has not invaded to any great extent. .

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The *Silbyum marianum* has in the Bay region become a common roadside weed, whose masses of handsomely veined foliage surpass in beauty many a carefully nurtured plant, but present an aspect of ragged dilapidation after the (annual) plant has completed its vegetation and sends its hairy-tufted akenes flying all over the country. Curiously enough, the *Silbyum* was for several years mistaken for the Canada thistle, and the legislation regarding the latter was partly enforced against it until the mistake was brought out in a lawsuit for neglect to comply with the law. Systematic mowing at the time of heading soon disposes of the plant, but when it has once gained possession for the season, it is hard to subdue, and shades out everything else.

The true Canada thistle was at one time imported into the State, and took possession of some land near Chico, Butte County, but was promptly recognized and subdued.

An experimental planting of the *Carduus benedictus* in the University garden revealed such dangerous qualities as a rapidly spreading weed that it was promptly extirpated.

Of the two *Xanthiums* mentioned above, the *X. spinosum* especially has become ubiquitous in the State, at least from Cisco to San Bernardino. Roadsides and fields are equally favored by it, and no summer drought or heat seems to affect it materially. Like the "black" cocklebur, it differs from the eastern form only in a lower and more spreading habit; and both are redoubtable weeds if neglected.

The entire tribe of rag-weeds (*Ambrosia*) is absent from the California list of weeds. The native *Franseria* is innocent.

Sonchus oleraceus, the milk thistle, and *Senecio vulgaris*, thrive as well in California as anywhere in the world, and are found throughout the settled portions of the State. The *Senecio* will germinate in the middle of the summer's drought almost as well as the *Centaureas*.

Erigeron Canadense affects chiefly the irrigated lands, and there demonstrates an unexpected resistance to even very strong "alkali," such as few useful plants could resist. In Fresno and Tulare Counties it reaches the height of eight feet easily, and forms thickets not pleasant to penetrate. In unirrigated lands it rarely becomes troublesome, and is of small stature, but nevertheless maintains itself fully where once established.

Cichorium intybus obstinately retains possession of fields where it has been cultivated, and spreads more or less, but outside of such cases the chicory can hardly be considered troublesome.

Matricaria discoidea is extensively diffused in the State, and lines the roadsides all over the Bay country, emitting its pleasant fragrance in the hot sun. *Chrysanthemum leucanthemum*, the ox-eye daisy, has gained a foothold in a few localities in the same region, but is not troublesome, and does not seem to spread rapidly.

Of native composites, the "tar-weeds" are the most objectionable; not so much because of their persistence as weeds as on account of the inconvenience caused by their viscid secretion, both to the person and clothes of the farmer, and to certain products. *Madia sativa* is the most generally obnoxious, both because of its almost universal occurrence in fields and roadsides, its extremely abundant secretion, and its disreputable aspect when covered with dust. An expensive bath of alcohol alone seems capable of removing the resinous slime from the injured clothes.

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Several *Hemizonias* are hardly behind the *Madia* in these respects, and several add to it a strong and sometimes disagreeable odor. Among these the *H. elegans* stands foremost, but this species is not often found in cultivated fields. The *H. luzulæfolia*, on the other hand, exhales a spicy odor of myrrh which is wafted over the harvest fields in July and August, and in a measure condones the disagreeable qualities of the plant, which really hurts the grain but little, attaining its growth after the crop is off the ground, and then seeding the latter most thoroughly when plowing cannot be done on account of the dryness of the soil. Several other species, however, are not so innocuous, as they grow up very rapidly among the grain while in milk, rendering it impossible to harvest without commingling it with the grain and then spoiling both straw and grain with its resinous exudation. They often form impassable thickets along the irrigation ditches.

The wild sunflower (*Helianthus annuus* or *lenticularis*), occurring naturally on rich and moderately moist soils, finds greatly increased opportunities for development when the land is cultivated, and sometimes covers the ground first broken completely, in defiance of crops sown. It is not, however, very persistent, and repeated mowing soon diminishes it to an easily manageable condition. But its complete extirpation is quite difficult. *H. Californicus*, occurring only in low, wet lands, is not very troublesome.

The place held in Europe and the East by the dandelion is measurably filled in California by several large-flowered species of *Troximon* (popularly called dandelions), and *Hypochæris*, whose feathered akenes fill the air in summer. They hardly invade the cultivated ground, but chiefly pastures and lawns. The true dandelion was at one time introduced as a matter of sentiment by an admirer, but showed such wonderful powers of development that it was, with some expense, extirpated from the threatened lawns.

Of other composites that invade the fields more generally but without doing any material damage, the beautiful *Layias* deserve mention. They make the ground gay beneath the half-ripe grain, and afterwards develop more fully. The *Achyrachæna mollis*, very inconspicuous while in bloom, sometimes forms a dense mat beneath the grain, and after harvest covers the field and fills the air with its beautiful silver-winged akenes.

Matricaria occidentalis invades the grain fields of the Bay region to some extent, but is not seriously troublesome.

The *Primulaceæ* furnish only the ubiquitous *Anagallis arvensis*, but this attains a degree of development which, from its prevalence in the moist European climates, would hardly be suspected. From early spring until the beginning of winter the multitudinous seeds of this little plant germinate, from the surface of moist soil or from the depths of that which is parched and hot, and with a tenacity of life worthy of a better cause. With the two *Centaureas*, the *Stellaria* and the *Erodium cicutarium*, it constitutes a group of weeds that form an exception to the prevalent rule, that after the cessation of rains the California farmer may consider the weed fight over for the season. In the northern part of the State its flowers have the usual dull red tint; in the southern their color is frequently purple or almost blue, and is so little recognized as the Old-World "Pimpernel" that it goes under the name of "poison chickweed."

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Of the *Apocynaceæ*, *A. cannabinum* invades pastures from the woodlands in the northern part of the State, but does not become troublesome south of Oregon and Washington.

Asclepias fascicularis maintains a place in cultivated fields of the "black adobe" character with some tenacity; *A. Fremonti* and *eriocarpa*, and locally *Gomphocarpus tomentosus*, maintain themselves in pastures, to the occasional detriment of sheep and cattle that are tempted to vary their dry summer diet with something green, and are poisoned by eating the leaves of these milk-weeds.

Of the *Gentianaceæ*, *Erythræa Muhlenbergii* keeps a place even in cultivated fields to some extent, and very commonly in pastures.

Of the numerous *Gilias*, only *G. squarrosa* rises to the dignity of a weed, both in pastures and cultivated fields, where its spinous leaves and bracts, and, above all, the intense odor that has given it the name of skunk-weed, render it obnoxious. Its viscous tomentum, covered with dust, gives it a forlorn aspect, and one sees with surprise the small, blue, starlike flowers amid this mass of dirt, spines, and fetor.

Phacelia tanacetifolia is the only weed from among the numerous *Hydrophyllaceæ*. Its prickly-hirsute stem and foliage render it an uncomfortable invader of the fields, and there is no compensation in its dull, yellowish-white flower-coils.

Among the *Borraginaceæ* two native *Amsinckias*—*A. intermedia* and *lycopsoides*—are truly troublesome in the coast ranges, maintaining themselves on the heavier clay soils which they naturally occupy, despite of cultivation and to the material injury of grain crops, with which, in many seasons, they share the ground evenly or prevalently. From the clinging quality of their hooked, hirsute tomentum, the *Amsinckias* have received the inappropriate name of "yellow tar-weed," although entirely innocent of resinous qualities. The nutlets accompany the bristly calyx on its migrations in the hair of cattle.

The *Convolvulaceæ* supply only two obnoxious members, one native—*C. Californicus*—and the European *C. arvensis*. These are not hurtful as "bind-weeds," but simply on account of obstinately holding their ground against culture plants by dint of their long rootstocks, that penetrate the ground to great depths, and which it is impossible to kill otherwise than by exhausting them—keeping the persistently reappearing tufts of foliage constantly cut during at least one season. The native species, which is erect, without creeping stems, is especially hard to subdue in the "black prairie" or adobe soils of the coast ranges, and its pretty white flowers adorn many an abandoned orchard in the Bay country. The *Convolvulus* is the most dreaded of the perennial weeds.

The *Cuscuta trifolii* is naturally a much dreaded pest in a country in which alfalfa is so important, and annually makes its appearance here and there, but is promptly checked by the simple expedient of close pasturing for at least one season. Alfalfa seed is usually required by the purchaser to be warranted "free from dodder."

Another dodder (*C. salina*) makes itself conspicuous in the coast marshes bordering San Francisco Bay, by large gold-tinted patches in the samphire growth; but of course it is otherwise innocuous.

Of the *Solanaceæ*, *Solanum nigrum* appears as a weed in waste places or fields, without being troublesome. The *Datura stramonium* has been introduced, but makes little headway, and is rare, while the native *D. meteloides* maintains itself obstinately against cultivation in the Great

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Valley and in South California, taking the place of the "Jamestown weed." Its range is nearly coëxtensive with that of one of the native tobaccos,

Nicotiana attenuata, whose viscous stems and foliage combine with an unpleasant odor to render it objectionable in the fields it invades.

Of the *Scrophulariaceæ*, the only weedy accession from the outside is an occasional occurrence of *Veronica peregrina*. *Scrophularia Californica* is locally troublesome; *Mimulus lyratus* is an obstinate, but hardly noxious, guest on the black lands of the Bay region and elsewhere. The most troublesome member of the family is *Orthocarpus purpurascens*, which not only disputes the ground with grain in the coast ranges, but must be strongly suspected of adding injury by semi-parasitism, etiolating the remnant of grain stalks. The same must be suspected as regards several others of the same genus that are frequent among the grain and in pastures in California, as well as of *O. campestris* of Oregon and Washington.

The cosmopolitan *Brunella*, though occurring in the mountain pastures of Northern California, obtains no foothold south of the Oregon line. *Stachys bullata* is locally troublesome in the Coast Range valleys; the intensely-scented *Trichostema* (camphor-weed) maintains itself in the cultivated fields of the warmer parts of the State as on its original ground, defying heat and drought, and playing the part of a "tar-weed" very successfully. But no other labiates can be counted as weeds.

The *Verbenaceæ* are represented only by *V. officinalis*, which, in the irrigated lands of the Great Valley and lower foothills, attains a vigorous development.

Of the *Plantaginaceæ*, *P. major* and *mollis* give some trouble in lawns and irrigated grounds, but cannot be considered troublesome. It is quite otherwise with *P. lanceolata*, which, in company with *Setaria glauca*, is the most formidable enemy of the irrigated grounds and pastures in the foothills of the Sierra, and more or less in the adjacent portions of the Sacramento Valley. This plantain frequently shares the ground evenly with the grain, and, in company with the *Setaria*, forms steadily increasing patches in the alfalfa fields, until the whole ground is taken. Such ground is difficult to reclaim from weeds, so long as field crops are grown.

In connection with the *Polygonaceæ*, it should have been stated at the beginning of this paper that the native *Rumex hymenosepalus*, whose tannin-bearing root is becoming an article of commerce, will persist quite obstinately in the sandy lands of the South, because of its many long, fleshy tubers that are not easily killed. Among the *Chenopodiums*, also, *Ch. ambrosioides* should have been mentioned as a common roadside weed, found in fields and waste places.

Urtica holoserica, the tall, stout native nettle, makes itself disagreeably conspicuous in low grounds; while *Urtica urens* is a common invader of cultivated grounds all over the State.

Of the *Euphorbiaceæ*, it is chiefly the decumbent tribe that represents the *Euphorbias* proper in the fields; notably *E. serpyllifolia*, of the East, and *albomarginata* and *ocellata*, as natives. All these are popularly credited with curative properties against rattlesnake bites. *E. lathyris* has locally escaped from cultivation, and is periodically brought forward as a much needed remedy for the troublesome "gopher," which, in sandy lands, it really seems to abate materially, probably through the poisonous properties of its pleasantly-tasting seeds.

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The most universally diffused weedy member of the order, however, is the *Eremocarpus setigerus*, a broad-leaved, hirsute, spreading annual, commonly known under the name of turkey-weed. While it prefers sandy soils, and is therefore more especially at home in the San Joaquin Valley, it is also found throughout the Sacramento Valley and within the coast ranges, from Mendocino County on the north to San Diego on the south. It does not even omit the Mojave Desert, but there changes its dichotomous spreading habit to an erect one, and appears in large patches densely crowded with almost unbranched stems, as much as three feet in height; suggesting the use of its strong and abundant fiber for industrial purposes. The extremely irritating nature of the dust arising from the dry stems when handled would alone probably prevent such use. The extreme resistance of the plant to drought enables it to survive almost any other annual vegetation; but the ease with which it is killed, even by a kick at the root-crown, renders it much less objectionable than most other "summer weeds."

Of the *Monocotyledons*, the true grasses only furnish really noxious weeds.

Anemopsis Californica, the yerba mansa of the Mexicans, maintains itself against cultivation in moist grounds with some obstinacy, but is not permanently troublesome.

Sisyrinchium bellum, the handsome blue "star grass," is apt to overrun moist but overstocked pastures, and is sometimes not easily subdued.

Oddly enough, one of the "California lilies," the pale blue *Calochortus invenustus*, Greene, is a veritable weed in some of the warmer parts of the State, where it persists in grain fields, though without material damage. A *Zygadenus* is charged with poisoning lambs and their hungry mothers in the early spring, in Northern California and Oregon.

Of the *Juncaceæ*, only *J. effusus* can be accounted as invading cultivated fields, in regions where it forms the natural growth in the woodlands.

None of the *Cyperaceæ* are at all troublesome in California.

Of weed grasses, the troublesome chess (*Bromus secalinus*) is found here and there, as an importation with seed-grain or packing-straw; but it utterly fails to gain a foothold as a weed. Its place is, however, very successfully occupied by the corresponding plant of Europe, the darnel (*Lolium temulentum*), which not only holds in the cereal fields a place similar to that held by the chess in the East, but is in addition charged with the same sin of transforming itself at will, in unfavorable seasons, into the very grain of which it has usurped the place—wheat, barley, oats, or whatever the crop may happen to be. The echoes of warm discussions on this issue, both in journals and in agricultural clubs, have hardly yet subsided, and there remains many a staunch believer in the changeling supposed to perform such surprising feats. Not the least amusing feature of this discussion is that Darwin was repeatedly cited as supporting and proving the occurrence of such transformations.

Lolium perenne, mostly in its Australian form, maintains itself sturdily against the summer's drought so far as its roots are concerned, and if cut will grow flower-stems three, and even four times in one season; still, it is not difficult to extirpate when so desired. *L. multiflorum* (annual) is common on roadsides, but is hardly troublesome.

Bromus mollis finds the climate much more congenial than does *B.*

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secalinus, and with *B. sterilis* may be classed as a weed-grass common on roadsides and in neglected fields. But it has attained a wide importance as a more or less welcome successor of the native grasses on natural pasture grounds, so completely adapted to the Coast Range climates that it may be found waving on the slopes as thickly massed as though sown on purpose. Locally it has been thus used, and is likely to become more popular, since it has been found to be effectual in driving out the most dangerous enemy among the grasses of both pastures and fields, viz.: the *Hordeum murinum*, variously known as squirrel grass, foxtail, and barley grass. This undesirable immigrant, while affording early green pasture for a short time, becomes a fearful nuisance so soon as its long-awned ears are developed. The bristly awns, provided like the paleæ with retrorse serration, accompany the three-flowered spikelets to the end; and the latter being sharp-pointed at base, adhere to and penetrate almost anything in the way of woolen or cotton materials from the sheep's fleece to ladies' dresses; they work up the nostrils of cattle, and the laborer's sleeves to the neck, and generally make themselves obnoxious to a degree not easily surpassed by any plant outside of the tropics. Although annual, its extirpation has proved extremely difficult; and the advent of a natural enemy in the "soft brome grass" is therefore most welcome.

The wild oat (*Avena fatua*) is so generally diffused, even in the remote portions of the State, that it is commonly considered indigenous, since it is mentioned by the early explorers as covering the hillsides of the coast ranges as well as Sierra foothills. While an unwelcome guest in the grain fields, it is highly esteemed for hay, despite its hirsute glumes that, when too ripe, sometimes give trouble in "choking" cattle not used to it.

Of the numerous paniceous grasses that trouble the Eastern farmer—the barnyard grass, crab grass, feather grass, and the several *Paspalums*—not one seems to gain a permanent foothold in the fight for existence. Only the purposely introduced *P. halepense* (Johnson grass) has in some sandy soils proved an almost ineradicable pest. The *Setaria glauca* is a terrible pest in the irrigated alfalfa fields of the foothills, as stated above.

Of the various *Poas*, only the *P. annua* can be counted as at all troublesome. The pestilent *P. Eragrostis* (*Eragrostis vulgaris*) does not maintain itself where introduced; and of the wild grasses, including those comprehended under the general name of bunch grasses (mostly species of *Festuca* and *Poa*), not one troubles the farmer save by the difficulty with which the turned-up rootstocks decay under the arid climatic conditions.

The most widely troublesome native grass is the *Distichlis maritima* ("alkali grass"), which long maintains itself in "alkali" ground, particularly in the lighter soils, in which its long rootstocks penetrate to depths of several feet and propagate from any fragment of a few inches, especially in irrigated lands; resembling, in this respect, the Bermuda grass as known elsewhere. The latter, however, can in California do no more than hold its own where planted, except on the borders of ditches; for the reason that during the dry summer its runners are unable to cast root, thus preventing its spread.

The eagle *fern*, common on the northward slopes of the coast ranges, maintains itself somewhat obstinately here, as it does in Oregon and Washington; but persistent cultivation for a few years overcomes it.

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While the above enumeration seems, at first sight, to present the weed question as somewhat formidable in respect to the number of species concerned, yet as a matter of fact, "getting into the grass," that constant bugbear of the Eastern farmer, confronts the California cultivator only in exceptional seasons; and with ordinary and intelligent care, adapted to the nature of the local weeds, he can usually rest from the weed war from June to November, or whenever the rains happen to set in. In the older cultivated regions, in fact, the extirpation has frequently been so complete that in the absence of the supply of vegetable matter usually furnished by plowing-in of weeds, the green-manuring of the clean orchards and vineyards is being seriously taken in hand.

SOME BERKELEY WEED-SEEDS.

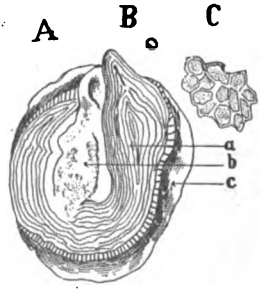
Graduating Thesis, by HUBERT P. DYER; Class of 1890, University of California.

[NOTE.—The descriptions and figures of weeds and weed-seeds, given below, form part of a work very needful to be done for this State, and the doing of which by students has been specially encouraged, because the time of the regular staff does not permit of its performance to any serious extent thus far. The existing works on the subject figure but few of the weed-seeds most interesting to the California farmer, and in the exclusion of which from the seeds he sows he is especially interested; hence, the determination of the purity of what he buys is rendered doubly difficult. The paper here presented is admittedly a mere fragment, but valuable as far as it goes. As time progresses we hope to increase, and ultimately complete, the description and figuring of California weeds and weed-seeds.—E. W. H.]

CRUCIFERÆ. (Mustard Family.)

This family furnishes those pests, the common mustards, and also the wild radish, a seed of which is shown in the drawing.

Raphanus sativus.—This is a coarse annual or biennial, and, like most of our worst weeds, is an introduced species escaped from cultivation. It can be easily recognized by its resemblance to the domestic radish



Seed of Raphanus sativus.

A. Position of the embryo seen in section. *a.* The embryo: yellow, clear. *b.* Yellowish, granular: starch. *c.* Exterior of seed. *B.* Natural size. *C.* External markings on seed-covering; color dead brown.

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when "gone to seed." Its seeds ripen in the middle of the spring season. The plant is difficult to eradicate, because it sprouts from the roots when cut.

Capsella Bursa-pastoris, or "Shepherd's Purse."—This is a very common annual, found growing from two inches up to almost two feet in height, in gardens, along roadsides, and in other carelessly tended spots.

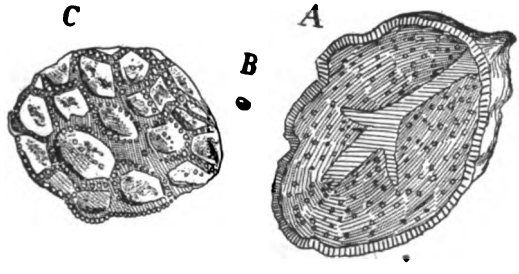
Seed of Capsella Bursa-pastoris.

A. Shape and appearance; greatly magnified. *B.* Natural size; color amber brown. *C.* Cross-section.

It has a small white flower, radiating leaves, and thin, triangular fruit-pods. By good early cultivation it is readily killed.

PAPAVERACEÆ. (Poppy Family.)

Eschscholtzia crocea, or California Poppy.—This is a showy plant, hardly to be ranked as a weed, although reappearing persistently when culture ceases.



Seed of Eschscholtzia crocea.

A. Seen in cross-section. *B.* Natural size; color dull brown. *C.* External markings.

GERANIACEÆ. (Cranesbill Family.)

Erodium moschatum, or "Musky Filaree."—In many places this species is displacing the *E. cicutarium*, the true alfilerilla, a valuable forage plant; on the University grounds it becomes a very obnoxious weed. Its propagation is assisted by the peculiar structure and form of the seed-vessel, which, under the alternate moisture and drought of our seasons, twists about and forces the seed into the ground.

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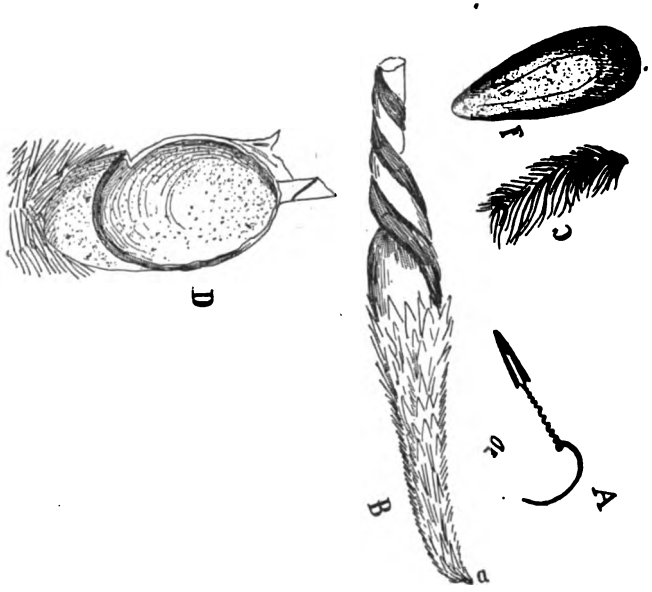
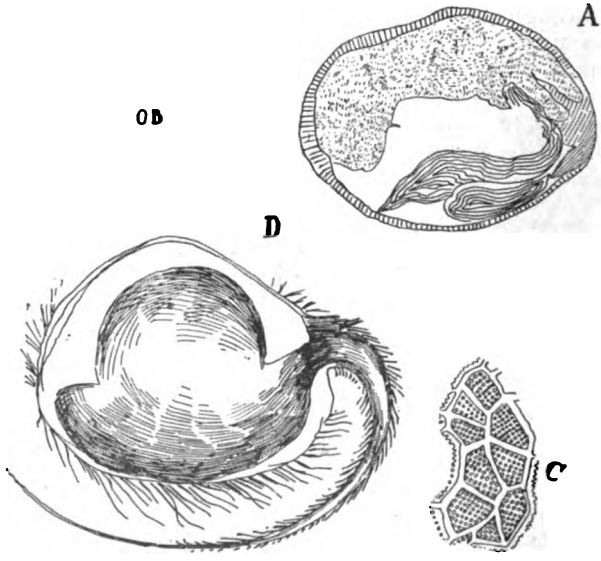


Seed of Erodium moschatum.

A. Natural size of seed-vessel. *B.* Showing seed-vessel enlarged. *a.* Seen in *C* enlarged. *C.* Barb of seed-vessel. *D.* Upper end of seed-vessel. *E.* Natural size of seed. *F.* Seed enlarged; external markings, very minute dots.



Seed of Geranium Carolinianum.

A. Seen in cross-section through center of seed. *B.* Natural size. *C.* External markings on seed: white ridges between the finely circular-marked spaces, which are black. *D.* Seed-vessel greatly magnified.

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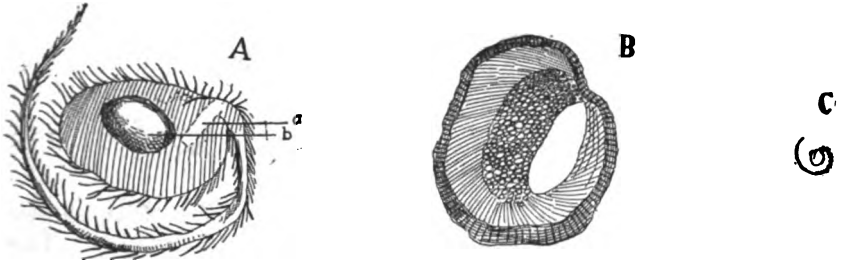
Geranium Carolinianum, often called "Carolina Cranesbill."—It is a low (six to eighteen inches), much branched, erect annual or biennial plant, with short-stalked, deeply five-parted leaves, the divisions cut-toothed, and small rose-colored flowers. It is only found occasionally, and is, in consequence, not troublesome. Its seeds are expelled from the seed-vessel by two prong-like springs, which throw the seed out with considerable force.

G. dissectum.—Similar to the last, differing in the more sharply pointed foliage, deep purple corolla, and more strongly netted seeds.

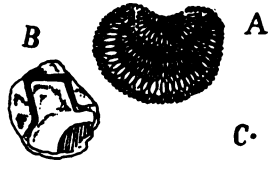


Seed of Geranium dissectum.

A. Showing position of seed in pod. *a.* Prong which expels the seed. *b.* Seed in position. *B.* Seen in cross-section. *C.* Natural size.

CARYOPHYLLACEÆ. (Pink Family.)

Silene Gallica.—This is an Old-World weed, widely prevalent and apparently drought-proof, equally in waste grounds and cultivated fields; grows six to ten inches high, with slender, dry, scantily-leaved stems and pale pink flowers, borne on one side. It is a slender, hairy plant, with spatulate leaves. It is not a serious pest, although rather a serious nuisance to smaller cultures; easily killed, but, on account of the multitude of its minute seeds, not easily eradicated.



Seed of Silene Gallica.

A. Shape and surface appearance of seed; color black. *B.* Seen in cross-section, normal to *A*. *C.* Natural size.

PORTULACCACEÆ. (Purslane Family.)

Claytonia perfoliata.—This is a low fleshy herb, with a shield-shaped leaf at the base of a flower stem, bearing small white flowers; called by some "Indian Lettuce." It grows in the spring in cool damp places, with *Stachys bullata* and *Calandrinia Menziesii*. It is not specially troublesome.

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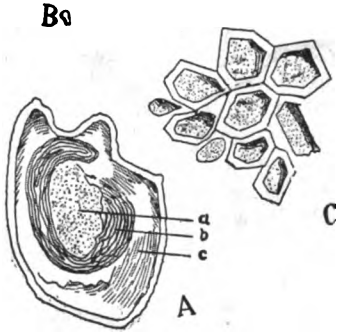
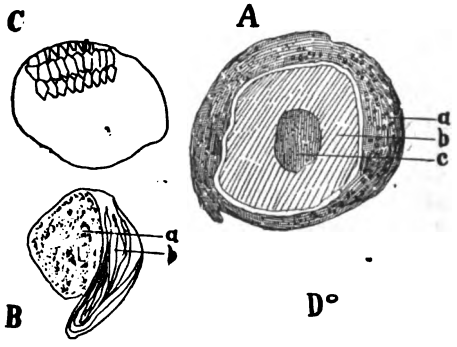


Seed of Claytonia perfoliata.

A. Position of embryo, seen in section. *a.* White starch. *b.* Albuminoid substance. *c.* Brown seed-coats. *B.* Natural size. *C.* External markings on outer seed-coat; color shining black.

Calandrinia Menziesii.—This is a low-branching herb, with showy rose-colored flowers; quite common in wheat fields and orchards. The ease with which it yields to cultivation renders it of little consequence, although it is not easy to eradicate it entirely.



Seed of Calandrinia Menziesii.

A. Seed seen in section. *a.* Seed-coats. *b.* Yellowish albuminoid substance. *c.* White starchy albumen. *B.* Shape and position of embryo. *a.* White starchy albumen. *b.* Embryo, yellowish. *C.* External markings of seed-coat; color shining black. *D.* Natural size.

MALVACEÆ. (Mallow Family.)

Malva parviflora.—This is an introduced plant, very common in cultivated ground, and commonly called the "Malva." In rich, moist soil, it reaches a considerable size, and if left to itself will soon become difficult to destroy. This is one of the commonest weeds about the University grounds, and also throughout most of the State, being a serious pest in orchards and vineyards.

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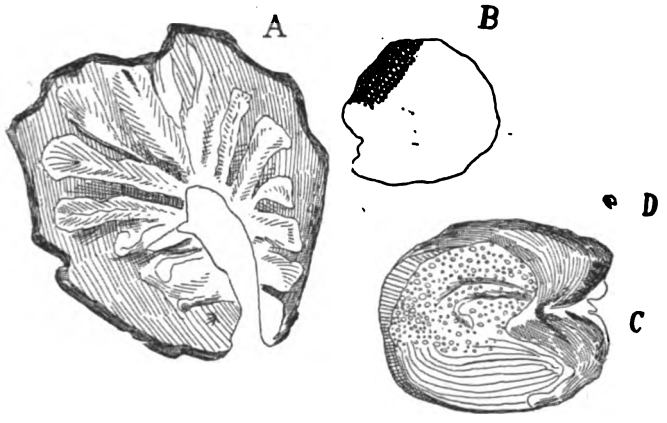
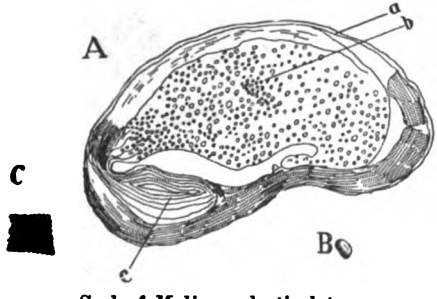


Seed of Malva parviflora.

A. One nutlet of fruit; greatly enlarged. *B.* Shape of nutlet and external markings. *C.* Seen in partial cross-section. *D.* Natural size.

LEGUMINOSÆ. (Pea Family.)

Medicago denticulata, or "Burr Clover."—This is in many places a valuable (dry-) forage plant, but at the University it is a troublesome weed.



Seed of Medicago denticulata.

A. Seed seen in section. *a.* Thin shell coat. *b.* Tail of embryo: granular. *c.* Head of embryo. *B.* Natural size. *C.* External markings; very minute; color light yellow.

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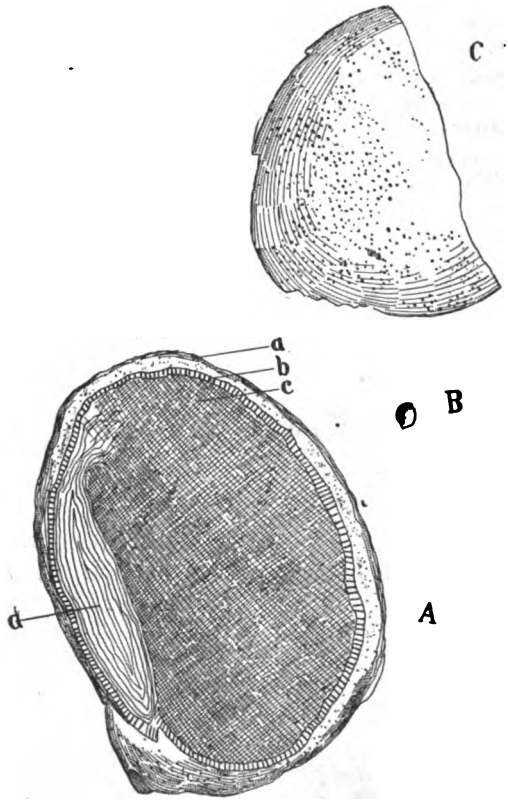
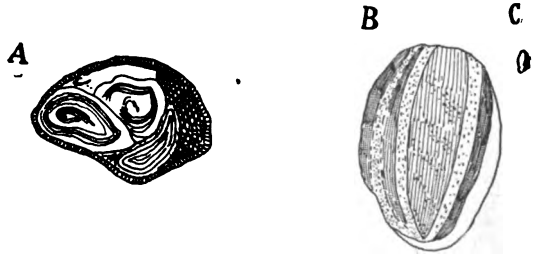
Lupinus micranthus.—This occurs in open fields and pastures, but is not at all troublesome, because of its slow growth; it is easily destroyed.



Seed of Lupinus micranthus.

A. Seed in section; showing embryo. *a.* Seed-covering. *b.* Section of covering. *c.* Granular substance. *d.* Head of embryo. *B.* Natural size. *C.* Portion of seed, showing external markings; black dots on a white shining surface.

Trifolium gracilentum.—One of the ordinary annual field clovers, and a very good pasture plant.



Seed of Trifolium gracilentum.

A. Shown in cross-section. *B.* Showing external markings. *C.* Natural size.

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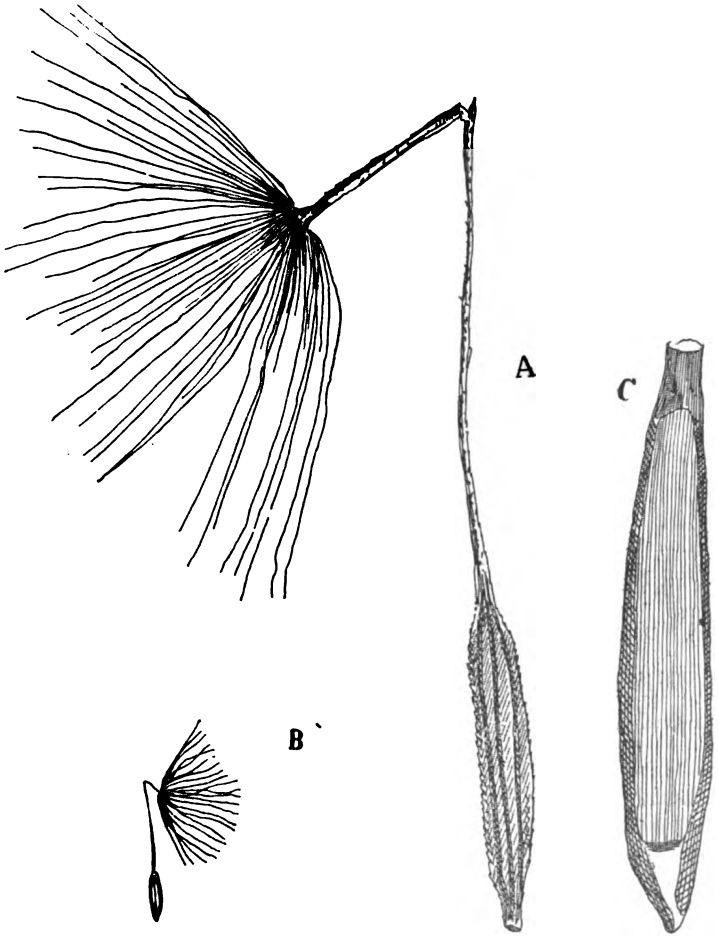
Compositæ. (Sunflower Family.)

Cichoriaceæ. (Chicory sub-family.)

Agoseris plebeia.—Called by many "dandelion," but wrongfully, as it is of a different genus, the true dandelion being a *Taraxacum*. It is a perennial, from twelve to eighteen inches high, leaves all radical, large yellow heads borne on a long slender scape. It is found in open dry fields and pastures, with the clovers and other *Compositæ*. It is not very troublesome, as it can be easily killed by an ordinary hoeing; but it spreads rapidly in lawns and pastures.



Seed (akene) of Agoseris plebeia.

A. Greatly magnified to show appearance of akene. *B.* Natural size. *C.* Seen in section.

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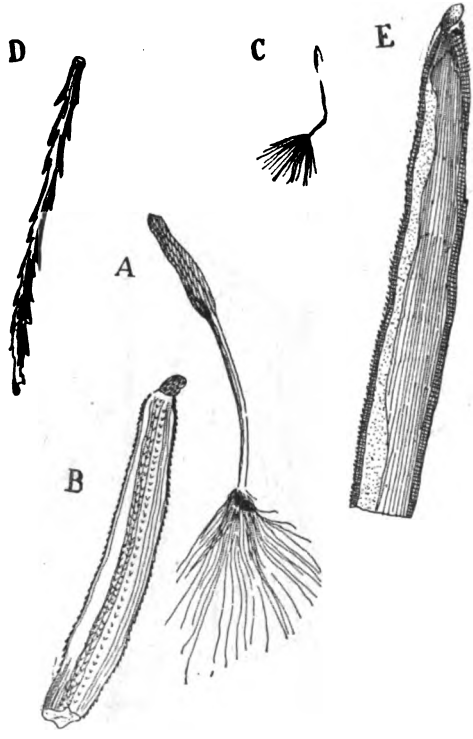
Agoseris hirsuta.—In appearance this is similar to the last, but somewhat smaller. It is a perennial found in dry, hard ground; it seems to do best in hot, dry places, especially on sunny slopes. It is easily eradicated individually, but a prolific seed-bearer, and, in consequence, a rapidly spreading weed. Like all *Cichoriaceæ*, its seeds are scattered far and wide by the wind; hence, it should be destroyed before it ripens its seeds.



Seed (akene) of Agoseris hirsuta.

A. Akene and pappus; enlarged. *B.* Portion of akene, showing markings and cross-section. *C.* Natural size; color dull straw; pappus white. *D.* Magnified view of one hair of pappus. *E.* One half of akene shown in section.

Calais Lindleyi.—This is a low annual, from four to eight inches in height, found along roadsides and other dry waste places. It is hardly a pest, as it cannot stand good cultivation. When once secure in a field it is, however, quite tenacious. It bears many seeds on a slender leafless scape.

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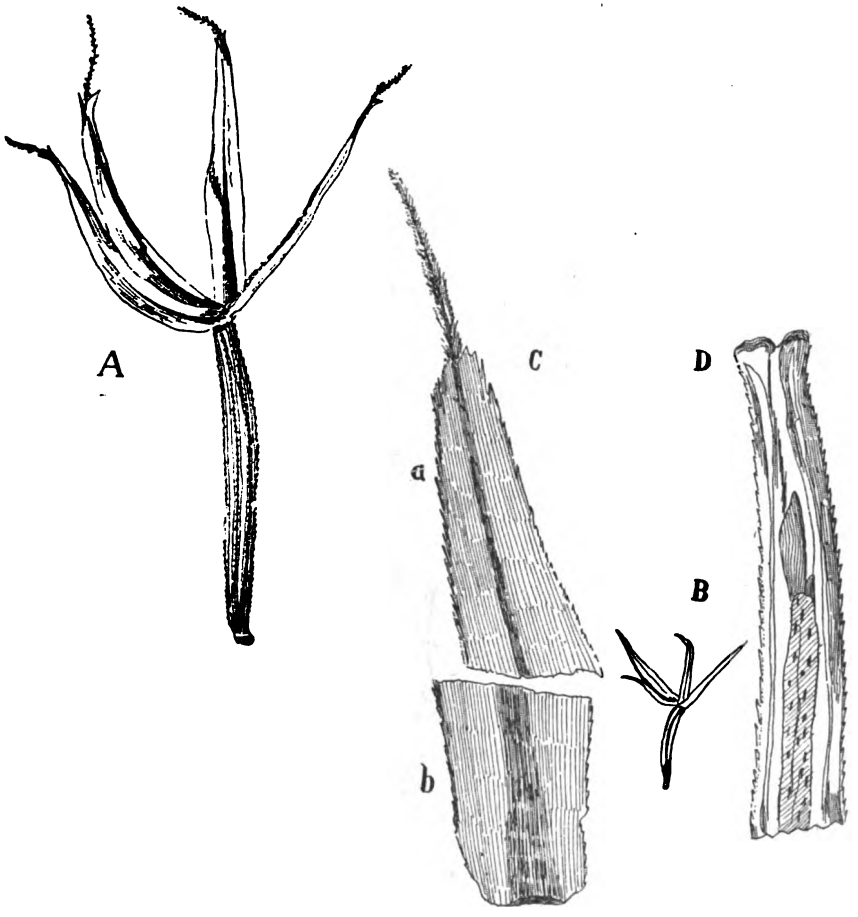

Seed (akene) of Calais Lindleyi.

A. Showing minute markings of akene. *B.* Natural size. *C.* One scale of pappus. *a.* Tip. *b.* Base. *D.* In partial section; showing kernel, also in section.

Hypochæris radicata.—A perennial, related to the dandelion, but the rosette of depressed leaves is hairy; the stem is almost leafless, branching and bearing a considerable number of scattered yellow dandelion-like flowers. In the University lawns this is a troublesome weed, but hardly rises to the dignity of a pest. It is also very common in Oakland lawns, where it seems to produce many crops of seeds in a season. As will be seen from the figure, two different forms of the fruit are found in the same flower-head.

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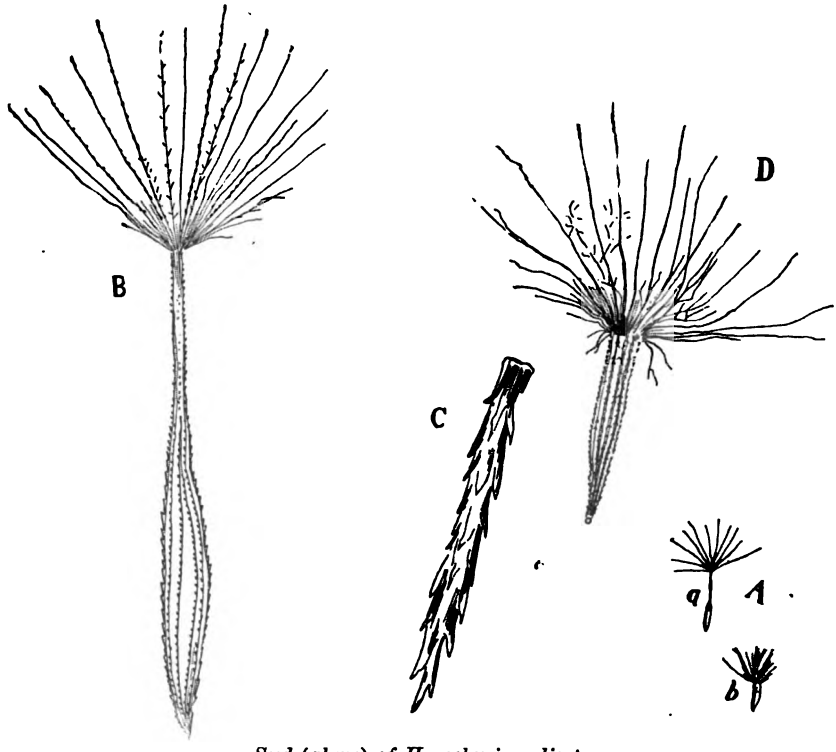

Seed (akene) of Hypochæris radicata.

A. Natural size. *a.* Stipitate pappus. *b.* Sessile pappus. *B.* Showing stipitate pappus and external akene markings. *C.* Portion of one hair of pappus. *D.* Showing seed with pappus sessile on the summit of the akene.

Sonchus oleraceus.—This is commonly called "sow thistle," and by some, on account of its white juice, "milk-weed." It is a ragged-looking annual, found mostly in waste ground and around rubbish, but also a persistent invader of cultivated fields and gardens. The stem is a large, angular, hollow column, quite fragile, and from two to three and one half feet in height. The large, wavy leaves are armed with weak spines. It is a very tenacious weed, but not specially troublesome, although a nuisance in pastures and about other uncultivated ground. It yields readily to the cultivator and hoe, but will sprout vigorously from any portion of the stem left connected with the root. It is eaten greedily by cattle and horses. It was introduced from Europe.

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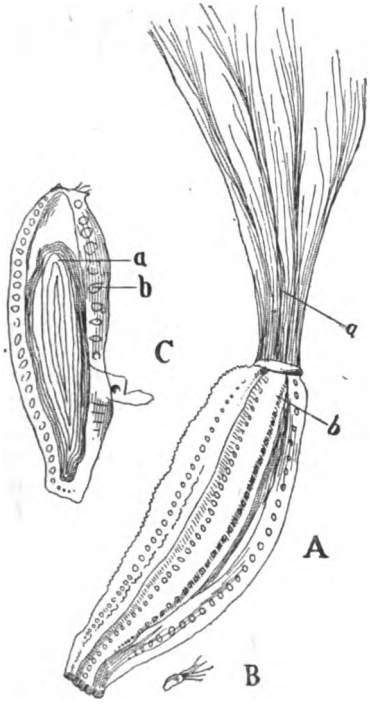

Seed of Sonchus oleraceus.

A. Akene with pappus; greatly magnified; color yellowish brown. *a.* Pappus. *b.* External markings. *B.* Akene with pappus; natural size. *C.* Form and position of kernel. *a.* Seed. *b.* Shell.

Matricaria discoidea.—This is a very disagreeable, troublesome annual weed, growing in masses six to eight inches high, with green ribs, yellow flower disks, devoid of ray-flowers, and finely divided leaves covering the stem; of a rather pleasant chamomile odor. It delights in the most unpromising situations, especially overgrowing the edges and unused parts of walks and roads, which places act as recruiting offices from which it branches out to interfere with everything. It is called by some "May-weed," but this is a mistake, as the commonly called May-weed is *Cotula.* Its seeds are so small as to be almost indistinguishable as such by the naked eye. Thorough cultivation will destroy it, but at the least cessation of care it resumes its attack. An interesting illustration of seeking favorable conditions is seen in the field south of the Experiment Station building. A path crossing the field is being slowly lined by this weed, which is pushing from each end towards the center. Throughout the field its size is small and growth feeble; at the path margins it is large and vigorous.

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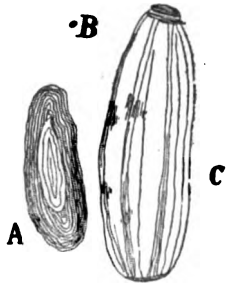
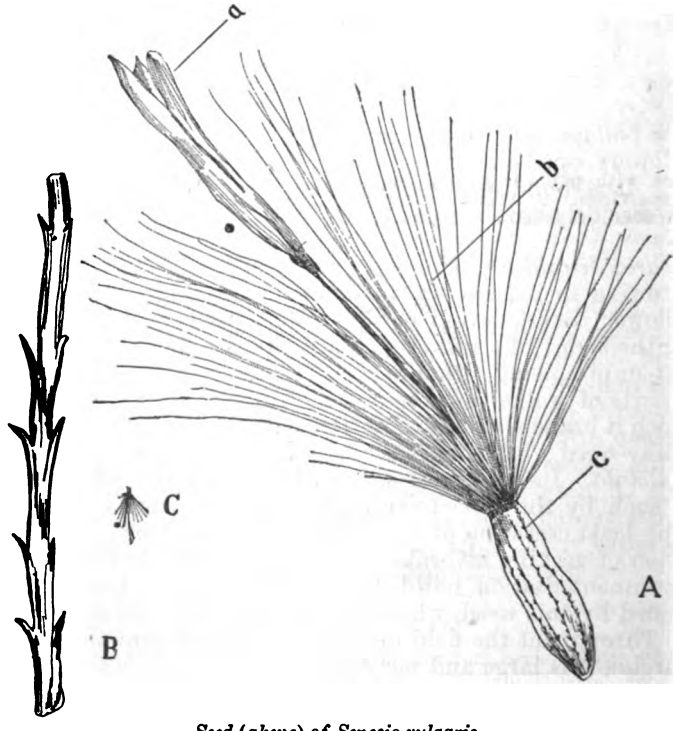


Seed (akene) of Matricaria discoidea.

A. Akene greatly enlarged. *B.* Natural size. *C.* Showing external markings.

Senecio vulgaris.—This is a common weed found everywhere and producing seed almost the year round. It is a low, slender annual with soft, hollow stems and oblong leaves obtusely lobed almost to the midrib, with yellow cylindrical flower-heads. Its prolific growth renders it a bad pest—in gardens chiefly, because of its untidy appearance; but if unchecked by cultivation, it will choke out everything else, its seeds germinating in the driest season.



Seed (akene) of Senecio vulgaris.

A. Greatly magnified. *a.* Old corolla. *b.* Pappus. *c.* Seed. *B.* One hair of pappus. *C.* Natural size.

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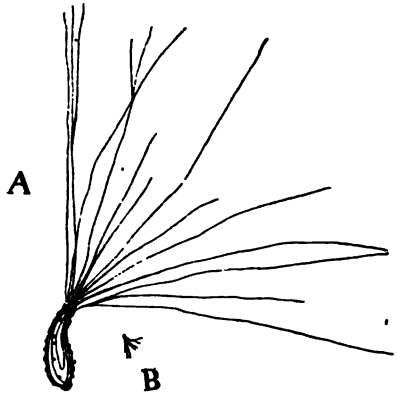
Gnaphalium purpureum (Purplish Everlasting).—This is a slender, soft, hairy annual, from twelve to eighteen inches in height; it is especially troublesome in pastures, but in fields it yields readily to ordinary cultivation.

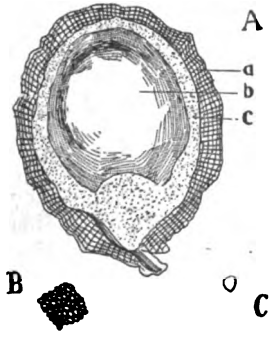


Seed (akene) of Gnaphalium purpureum.

A. Greatly magnified. *B.* Natural size.

LABIATÆ. (Mint Family.)

Stachys bullata.—This is a pretty little plant, with pink-colored, two-lipped flowers, opposite leaves, emitting a strong unpleasant odor when crushed. It is found in moist places in cultivated fields and orchards. It is not seriously troublesome.



Nutlet of Stachys bullata.

A. Seen in section across middle of nutlet. *a.* Seed shell. *b.* Albuminoid matter. *c.* embryo. *B.* External markings of nutlet; color dull brown. *C.* Natural size.

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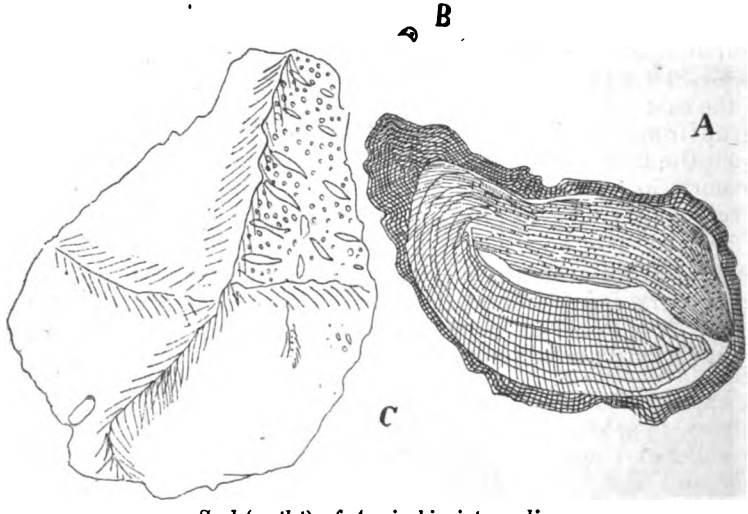
BORRAGINACEÆ. (Borrage Family.)

Amsinckia.—This genus, although a close relative of the "forget-me-not," furnishes the farmer one of the most formidable weed pests. It will completely ruin a grain field if unchecked; in fact, if it gets a start in a growing wheat field, there seems to be no known remedy for the season. The best thing to do is to take care that it is not introduced by means of its seed being mixed with the seed-grain; this can easily happen, because the Amsinckia seed is small enough to escape detection unless specially sought for. The specimen shown in the drawing is that of *A. intermedia*, which is not, however, the worst pest. *A. lycopsoides* is the one that most commonly infests wheat fields, and is the most troublesome and dangerous. But good cultivation will destroy either, as they are annuals; only it will be necessary to omit at least grain crops for one or two years, and carefully prevent any from going to seed.



Seed (nutlet) of Amsinckia intermedia.

A. Seen in cross-section. *B.* Natural size. *C.* Shape and external markings.

The Amsinckias are often called "yellow tar-weed," although they are innocent of any tarry matter, but adhere by their hooked bristles. "Yellow forget-me-not" would describe the plant very well.

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REPORT ON TREES PLANTED ON MOUNT HAMILTON.

By K. McLennan.

In accordance with the instructions of the Director, I left Berkeley early in August, 1890, and proceeded directly to Mount Hamilton. After reporting to Prof. E. S. Holden, I spent several days in determining where it was best to begin and what varieties were best suited to different exposures. We first commenced to replace the dead trees, of the planting of the spring of 1889, along both sides of the main avenue leading from the astronomers' cottages and around Professor Holden's house. Here we used the following varieties of trees: *Libocedrus decurrens, Thuja gigantea, Pinus austriaca, Pinus Sylvestris, Cupressus Lawsoniana.* These were sent from the University propagating houses. We also planted the following named varieties, obtained from the California Nursery Company: *Picea nobilis, Picea concolor, Abies excelsa.* A number of *Sequoia sempervirens* were scattered here and there in the rows. On the bank above Professor Holden's house and in front of the workshop we planted *Juniperus Sabina,* obtained at the University. Several *Sequoia sempervirens* (redwood) were set in front of each of the cottages.

On the east side of the mountain, forty-five feet below the main road going up from the astronomers' cottages to the Observatory, and starting from the first cottage, we planted an avenue around the mountain to the north as far as the rocks would permit. This avenue was planted with redwood trees eighteen inches high, all balled and in good condition. We also planted on the east side, again around to the north, using groups of all the species named. Between the laborers' cottages and those of the astronomers, we planted Picholine olives and trees of the *Arbutus unedo,* all sent from the University grounds.

Observations made on trees planted in 1889 show that the *Cedrus deodara, Libocedrus decurrens* and *Mahonia aquifolia* were all living and doing excellently. *Sequoia gigantea* (Big Tree), *Cupressus macrocarpa* (Monterey cypress), *Pinus muricata,* and *Pinus insignis* (Monterey pine) suffered somewhat; some of them were entirely gone. *Picea concolor* and *Picea excelsa* were doing fairly well, as were also some almond trees that were planted at Professor Holden's house. All the other orchard trees that were then planted have perished, and the survival of the almonds is a very curious fact.

The total coniferous tree planting of this year consisted of one hundred *Redwoods,* fifty *Picea nobilis,* fifty *Picea concolor,* fifty *Abies excelsa,* sixty *Libocedrus decurrens,* and fifty *Cupressus Lawsoniana.* There are plants of *Abies Douglassii, A. Menziesii, Pinus ponderosa, Picea magnifica,* and other Pacific Coast trees now being grown in the University propagating houses for future use on Mount Hamilton.

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B. THE FOOTHILL STATION.

Five miles north-northeast from Jackson, Amador County.

By CHARLES H. SHINN.

The Foothill Station, near Jackson, Amador County, is attracting more attention than formerly, the number of visitors increasing, and the interest of the community in the work done there being more manifest. Since the last report was issued, several permanent improvements have been made. A large tank has been built on the hilltop near the house, and the reservoir planned for on the southern hill has been completed. It was cut in the rock, and cemented inside; another coat of cement was applied in August, to render it secure, and siphon pipes put in, so as to use the water on the orchard below. The pump in the mining ditch continues to work excellently, except that the grit in the water wears out couplings rapidly. A good deal of grading has been done on the land, new roads cut, new gates put in, the bridge near the station rebuilt, and in all respects the development of the farm continued as much as was possible with the amount of labor at the Foreman's diposal. The soil requires constant care, to prevent "washing out" during winter, or when irrigating, and dangerous places are gradually being protected by walls of rock. Glass for a propagating house, in which seeds and cuttings can be started, and plants that have suffered during shipment can be restored to health, has been sent to the station.

Notes upon some experiments with fertilizers at the station will be found elsewhere in this report.

THE ORCHARD.

During the planting season of 1890–91, the orchard was increased by such varieties as are at the other stations, but were unrepresented here. All the gaps left by failure to grow were replanted. The actual extensions thus made were slight. There is room for additional orchard, but another season is necessary to secure abundant stock of new varieties.

No *Apples* were sent from the Central Station, owing to the presence of woolly aphis on the stocks grown too closely on long-cultivated soil. The apples and other trees sent were carefully inspected and disinfected thoroughly so as to destroy all scale or other insect pests. Twenty-five apple trees were planted at the Foothill Station; three—Clotie, Early Ripe, and Stump—were new to this district. The apples already planted show fair growth, and promise better on the red soil than on the decomposed granite soil, which will probably need to be fertilized if heavy crops are to be obtained.

Pears show a decided gain in growth over the season of 1889, and particularly so in the case of the Japanese seedlings, some of which will be budded this year. Five or six of these Japanese seedlings show marked characteristics, freedom from thorns and clean appearance; they

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will be allowed to fruit. Only thirteen pear trees were required to fill the gaps.

Plums and *Prunes* are much the same as at the other stations. Peach, apricot, and Myrobalan are the stocks. Dormant buds, many of which failed, have been replanted. All the plums and prunes grow slowly, but the foliage is darker than in the valleys, and the growth is more stocky. Several new plums were planted this season. The Japanese varieties have fruited this year (1891), as at some other stations. It seems evident, that in the dwarf early Japan plums, and in seedlings and hybrids from them, the *true garden plum* for the millions has been discovered. Trees, that by measurement are less than thirty inches high, are loaded with fruit of excellent quality at three years of age (one-year trees, two years planted in orchard).

The *Apricots* have grown rather better on plum stock than on apricot, but it is too early yet to determine the relative values of these stocks for this soil. Among the new varieties are the Newcastle, and several other California seedlings.

Peaches and *Nectarines* are much the same in growth. Among the new peaches planted this season are Elberta, Noblesse, Bonanza, and Newhall. Twenty trees were sufficient to fill the gaps caused by loss of dormant buds. The gum disease noted in 1889 on the peach and nectarine roots has lessened, as the season of 1890 was more dry, and greater care was taken not to over-irrigate. Few of the trees received any water at all. The health, vigor, and beauty of most of the peach trees, particularly on the red soil, is very gratifying. Some fruit will be gathered this year; in fact, it has proved necessary to "thin out" some of the trees that were carrying too much.

Almonds continue to make rapid growth. This tree thrives, however, in many places where frosts prevent the fruit from "setting," and hardiness is the most important point to be considered. The list of varieties planted is now so complete that we only need to add new seedlings of promise as fast as they appear in different parts of California. As fast as varieties are proved too tender, or otherwise ill-adapted to the region, they can be "worked over," so as to test other sorts.

Cherries have been a surprise. Only six failed in the orchard, and have been replaced. The growth of the trees was most excellent. They are on the stronger (red) soil, and well sheltered. It is too soon to determine whether or not they have the strong tendency to gum disease and cracking of the bark that renders the cherry an uncertain crop in so many places in the foothills. At present there is no sign of this trouble. Some of the largest cherry trees in the State are on farms of the Sierra foothills; but only a few districts, such as Newcastle, can show much cherry planting on a commercial scale. With the steady increase in demand for the finer cherries, a larger area of red foothill lands could be profitably employed in cherry culture.

Figs continue to grow well, and many cuttings have been rooted at the station. The fig avenues have been extended completely around the reservoir hill, and the fig will be used in many other places for ornament and utility. The "Bulletin" Smyrnas are among the strongest growers. Rocardi, Ronde Noir, and Negro Largo are, among the new varieties, particularly good trees. All, without exception, are evidently at home on all the soils of the station.

The *Olives*, so well represented here, attract more attention from vis-

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itors than any other culture. The entire avenue is complete. The granite soil shows excellent growth, and the red soil shows still better. All parts of the station farm are adapted to the olive. Among the best, and showing some blossoms this year, are Rubra and Uvaria. Nevadillo blanco is the strongest grower. Manzanillo and Oblonga are also especially attractive. There will be a demand among the Italian settlers in Amador County for all the olive stock that the station can possibly spare. The fig, grape, and olive are the three cultures that seem to appeal most forcibly to the land owners in the immediate district.

Among the nut-bearing trees the *Walnuts* make the best appearance. *Pecans* come next, and ripen foliage early, so that the fruit will probably mature at the proper season. In the San José Valley the pecan does poorly in this respect, the nut seldom falling till late in spring. The *Chestnuts* grow poorly at the Foothill Station, though the Italian and Japanese promise better than the American.

REPORT ON THE GROWING OF GRAINS IN 1890 AND 1891 AT THE FOOTHILL STATION.

By George Hansen.

Below we give lists of all those varieties of grains which have been sown in trial beds of different sizes all over the station ground, provided they were not in the way, and allowed of easy inspection. They are self-explanatory in the main, showing first, the different heights of the grains on our two chief soils, under different conditions of sowing and rainfall; marking those which were worthy of special notice, whether good or poor. Thus far it is difficult to say whether one or the other variety is best adapted to this or that soil—nearly as hard as it is to tell of what character the rainy season is likely to be. The object in sowing and resowing our grain for so many consecutive years, is to find out how the several kinds prosper, under the various conditions of weather or season, on the several soils at our command. For instance:

The sowing of 1890 took place in the time from February 2d to March 1st. The winter had been unusually wet, almost too wet to do any work, there having fallen at the station nearly sixty inches of rain, and as many of snow. In spite of the late season, the grains were sown just to see how they would turn out. That year they received, during their time of growth, a rainfall of 17.57 inches and 15.7 inches of snow, divided as follows: February, 4.43 inches of rain and 15.7 of snow; March, 8.18 inches of rain; April, 2.49 inches of rain; May, 2.47 inches of rain. The last rain came May 11th, and to secure any success we had to hoe the beds to loosen the ground and to prevent the soil from drying out in the hot time following. July 31st, we gathered the last ripe seed.

The season of 1891 was more favorable, though the grains (on account of pressure in the bust season) were not sown till January 15th. The rainfall amounted to 19.45 inches, divided over the months: January, none; February, 6.55 inches; March, 6.36; April, 4.09; May, 1.18; June, 1.27; the last rain, of 1.27 inches, coming down June 12th. The last rain, damaging as it was to the hay crop, was the making of our grain trials, as it was for seed-growing generally. If we had had such a late rain the year before no hoeing would have been needed.

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The wonderful difference in results caused by the different seasons is easily seen by comparing the columns. I did not comment on the quality of the grain grown in 1890, because all were put in so late that perhaps but few farmers in our foothills would think of sowing at all if they could not have found time earlier in the year. Still, there were quite a number who did risk the outlay in seed (barley could hardly be purchased for $42 up here), hoping for late rains. Some were successful; others would not trouble with mowing such low stalks as they found on their fields, and turned their stock on them. For these, our experiment of 1890 is of value, for they can find, in the tables, quite a number of varieties that would have proved worthy of reaping, in spite of the advanced season.

In regard to the different soils, I must say that though we have the red and the granite soils of the foothills represented, and always speak about them as the two chief varieties, there are really many more soils on our grounds. For instance, the granite soil is, in part (on the lower ground), so exceedingly poor, that on a field of wheat sown where we had quite a number of little grain-beds last year, one could have marked, within a couple of inches, the walks and borders of the bed by the difference in the color of the grain—it looked somewhat like a chess board. The granite soil on which the grain was sown this year lies on a low slope, and is comparatively rich, from an admixture of wash from the red soil. As a striking example, I mention Nepaul barley, which, the year before, attained a height of but twenty-four inches, this year grew forty-one inches high; the same can be said of portions of the red soil. We have spots too sandy to be adhesive, even if wet, and too stiff to break up when dry, rich enough to grow Surprise oats five feet high in a poor season, and too poor to allow Red Emmer wheat to grow higher than twenty-seven inches, whereas, in fairly good granite soil it grew forty-seven inches.

Our experiments are, of course, quite incomplete as yet; they will be carried on further, and the lists extended and completed by the results obtained through earlier sowing and different seasons.

WHEATS.

Variety.	Year.	Average Height.		Seed Ripe.		Remarks.
		Red Soil.	Granite Soil.	Red Soil.	Granite Soil.	
Archer's Prolific	1890	30 in.		July 23		
	1891		43 in.		July 4	Good heads.
Arizona Indian Seed	1890	30 in.		July 24		
	1891		42 in.		July 6	Good heads.
Black Centennial	1890	55 in.		July 22		
	1891		58 in.		July 21	Very good.
Blue Glass	1890	33 in.		July 23		
	1891		40 in.		July 8	
California Spring	1890	34 in.		July 23		
	1891		39 in.		July 10	Good.
Champlain	1890	39 in.		July 23		
	1891		48 in.		July 4	
Clawson	1890	42 in.		July 23		
	1891		49 in.		July 10	Good.
Defiance	1890	36 in.		July 23		
Diamond (Polish)	1890	52 in.		July 23		
	1891		50 in.		July 20	Good.
Egyptian	1890	50 in.		July 21		
	1891				July 14	Good.
Fern (April)	1890	46 in.		July 23		

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WHEATS—Continued.

Variety.	Year.	Average Height.		Seed Ripe.		Remarks.
		Red Soil.	Granite Soil.	Red Soil.	Granite Soil.	
Forelle	1890	39 in.		July 23		
	1891		41 in.		July 15	Poor.
Frankenstein	1890	37 in.		July 23		
	1891		48 in.		July 19	Good.
Genoese	1890	35 in.		July 23		
	1891		46 in.		July 9	
Ghurka (Odessa)	1890	38 in.		July 23		
	1891		43 in.		July 4	
Greek Atlanti	1890		39 in.		July 31	
	1891		45 in.		July 4	Good.
White Victoria (Hallett's pedigree)	1890		35 in.		July 31	
	1891		11 in.		July 22	
Harris from Jasper	1890	34 in.		July 23		
	1891		43 in.		July 4	Poor.
Hungarian (Brenner)	1890	32 in.		July 23		
	1891		47 in.		July 4	Good.
Hungarian (Burke)	1890	30 in.		July 24		
	1891		43 in.		July 16	Good.
Improved Circassian	1890	37 in.		July 24		
	1891		48 in.		July 6	Poor.
Indian (three months)	1890	37 in.		July 24		
	1891		44 in.		July 12	Poor.
Indian (winter)	1890	37 in.		July 24		
	1891		42 in.		July 10	Poor.
Missoyen	1890		40 in.		July 31	
	1891		46 in.		July 6	Very good.
Nicaragua (E. K. Carr)	1890	50 in.		July 23		
	1891		52 in.		July 12	Very good.
Nonette Lousanne	1890	40 in.		July 24		
	1891		45 in.		July 12	Good.
Nonpareil	1890	36 in.		July 28		
	1891		45 in.		July 10	Good.
Oregon Big White Club	1890	36 in.		July 28		
	1891		45 in.		July 6	Very good.
Palestine	1890		21 in.		July 31	Very poor.
	1891		32 in.		July 6	Good heads.
Petali	1890		30 in.		July 31	Very poor.
	1891		41 in.		July 8	
Pringle's Best	1890	37 in.		July 25		
	1891		42 in.		July 23	
Pringle's Defiance	1890	39 in.		July 25		
	1891		39 in.		July 5	
Proponti	1890	34 in.		July 25		
Red Club (Hedgehog)	1890	36 in.		July 25		
	1891		47 in.		July 4	Very good.
Royal Australian	1890	36 in.		July 28		
	1891		51 in.		July 6	Good.
Russian Red-Bearded	1890	34 in.	35 in.	July 28	July 31	Grit a failure.
	1891		44 in.		July 4	
Snowflake	1890	37 in.		July 25		
	1891		48 in.		July 12	Very good.
Taganrog	1890	48 in.		July 25		
	1891		48 in.		July 6	Heavy heads.
Thuringian	1890	37 in.		July 25		
	1891		48 in.		July 21	Very good.
Tonzelle	1890	31 in.		July 25		
	1891		43 in.		July 23	Very good.
Tunisian	1890	49 in.		July 25		
	1891		50 in.		July 23	Poor heads.
Victoria	1890	34 in.		July 31		
	1891		41 in.		July 19	
Volo	1890	33 in.		July 26		
	1891		46 in.		July 21	Poor.
Whittington	1890	32 in.		July 25		
	1891		51 in.		July 8	Good.
Yellow Noé	1890	39 in.		July 26		
	1891		48 in.		July 6	Good.

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The varieties of wheat sown in 1890 were sown also in soil consisting of a mixture of red and granite soils; the difference in the height of the grain was not worth recording.

BARLEYS.

Variety.	Year.	Average Height.		Seed Ripe.		Remarks.
		Red Soil.	Granite Soil.	Red Soil.	Granite Soil.	
Berkeley Hybrid	1890		26 in.			
	1891		30 in.		July 8	
Black, six-rowed	1890		30 in.		July 8	
	1891		40 in.		July 2	
Bluish	1890		27 in.			
Carter's Prolific	1890		30 in.		July 8	
	1891		37 in.		June 30	
Chevalier	1890		30 in.		July 7	
	1891		36 in.		June 30	
Early Black, six-rowed	1890		36 in.		July 7	
	1891		35 in.		June 27	
Himalaya	1890		30 in.		June 26	
Hallett's pedigree of Chevalier	1890		30 in.		July 14	
	1891		36 in.		July 2	
Imperial	1890		32 in.		July 14	
	1891		40 in.		June 30	
Italian	1890		36 in.		July 7	
	1891		40 in.		June 30	
Kalina	1890		32 in.		July 9	
	1891		43 in.		July 5	Good.
Large Naked, two-rowed	1890		27 in.		July 19	
	1891		39 in.		July 2	Poor.
Mandchurian	1890		34 in.		June 30	
	1891		30 in.		June 29	
Nepaul	1890		24 in.		July 19	
	1891		41 in.		July 24	Good.
Rice	1890		32 in.		July 23	
	1891		37 in.		July 25	
Scotch, two-rowed	1890		26 in.		June 30	
	1891		32 in.		July 2	
Six-rowed (Brenner)	1890		29 in.		July 19	
	1891		32 in.		July 2	Good.
Small Blue Naked	1890		30 in.		July 19	
	1891		37 in.		July 2	
Six-rowed Winter	1891		34 in.		June 26	

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OATS.

Variety.	Year.	Average Height.		Seed Ripe.		Remarks.
		Red Soil.	Granite Soil.	Red Soil.	Granite Soil.	
Bald	1890	32 in.	33 in.	July 12	July 19	
	1891		46 in.		July 7	
Black Tartarian	1890	42 in.	35 in.	July 12	July 31	
	1891		45 in.		July 10	
Canadian	1890	52 in.	37 in.	July 8	July 14	
	1891		56 in.		July 5	
Early August	1890	42 in.	31 in.	July 14	July 14	Very good.
	1891		50 in.		July 12	
From E. K. Carr, Texas	1890	28 in.	26 in.	July 8	July 15	
	1891		36 in.		July 10	
Early, from Caulomers	1890		27 in.		July 16	
Early, from Georgia	1890	38 in.	31 in.	July 14	July 14	
	1891		40 in.		July 14	
Gray oats from Houdan	1890	49 in.	43 in.	July 14	July 31	
Large Naked	1890	42 in.	30 in.	July 8	July 19	
	1891		42 in.		July 12	
Scotch Hopetown	1890	48 in.	42 in.	July 8	July 15	
	1891		52 in.		July 7	
Surprise	1890	51 in.	47 in.	July 8	July 17	
	1891		60 in.		July 15	Very good.
White Bolognese	1890	46 in.	45 in.	July 21	July 31	
	1891		55 in.		July 8	Very good.

RYES.

Variety.	Year.	Average Height.		Seed Ripe.		Remarks.
		Red Soil.	Granite Soil.	Red Soil.	Granite Soil.	
Excelsior	1890	49 in.	49 in.	July 28	July 30	
	1891		59 in.		July 5	
Perennial Saxon	1890	50 in.	45 in.	July 28	July 30	
	1891		62 in.		July 4	
Spanish Double-bearing	1890	42 in.	38 in.	July 28	July 30	
	1891		64 in.		July 10	Very good.
St. John's Day	1890	47 in.	43 in.	July 28	July 30	
	1891		68 in.		July 2	Good.
Swedish Sand	1890	43 in.		July 30	July 30	

The rye on granite soil sown in 1890 showed poor heads.

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SPELTS.

Variety.	Year.	Average Height.		Seed Ripe.		Remarks.
		Red Soil.	Granite Soil.	Red Soil.	Granite Soil.	
Blue-Bearded	1890	84 in.	-------	July 26	July 30	----------
	1891	-------	48 in.	-------	July 23	Very good.
Common White-Bearded	1890	29 in.	-------	July 26	July 30	----------
	1891	-------	47 in.	-------	July 6	----------
Red Emmer	1890	30 in.	-------	July 27	July 30	----------
	1890	30 in.	-------	July 27	July 30	Very good.
White Emmer	1890	30 in.	-------	July 27	July 30	----------
	1891	-------	47 in.	-------	July 12	----------
White Silesian	1890	84 in.	-------	July 29	July 29	----------
	1891	-------	46 in.	-------	July 20	----------

The red soil on which the spelts were sown in 1890 was of the most rocky kind imaginable.

FERTILIZER EXPERIMENTS AT THE FOOTHILL STATION.

The very small product of hay per acre realized on many of the foothill soils, notably on those of the granitic character, and directly the heavy expense annually incurred by the station in the purchase of its hay supply, rendered it desirable to try the effect of various fertilizers in increasing the crop. Some of the level land of the tract lying north of the Amador ditch, and of the purely granitic type, was used for this purpose; unfortunately it had just been cleared of a growth of chaparral and small oak, and the uneven condition rendered it difficult to apportion the experimental plots as might have been desired; hence it was thought best to use rather excessive amounts of fertilizers. The results of the season may therefore be considered as suffering with some uncertainties, yet the results, as hereinafter reported by Foreman Hansen, are sufficiently indicative of the direction in which increase of production is to be sought. The analysis of the soil had indicated that, while potash is abundant (as it is in most California soils), this granitic soil is very poor in phosphates and in humus, hence, inferentially in nitrogen. Hence, the fertilizers chosen for this first trial were bone dust and nitrate of soda; also, a prepared fertilizer supplied by the "Mexican Phosphate and Sulphur Company" of San Francisco. The brand "C" of that manufacture is reported to be composed as follows:

Phosphoric acid.....12 per cent.
Potash.....5 to 6 per cent.
Ammonia.....3 to 4 per cent.

Mr. Hansen's report is as follows:

REPORT ON THE EXPERIMENTS IN HAY-GROWING WITH THE AID OF DIFFERENT FERTILIZERS AT THE FOOTHILL STATION.

By GEORGE HANSEN.

The *McKay tract*, comprising about six and one half acres, lying at the north end of the station grounds, has been cleared. The Amador Canal lies on one side, and it and the debris of a cut in granite of an average depth of about twenty feet take up about two acres of it. Of

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the rest of the tract, two acres were put into condition to grow a crop of hay, partly in order to reduce the heavy outlay for hay required for the team (hay delivered averages $20 per ton), partly to experiment in hay-growing with the aid of fertilizers.

The clearing of the ground proved a rather heavy expense, costing fully $50 per acre on account of the numerous small oaks which had to be grubbed out. Only two acres could be got ready this season for experimenting. They are in the west half, in the shape of a parallelogram, the sides four hundred and forty and two hundred feet respectively, but deducting some rocky spots and the bends of the ditch, we could not make use of more than one and four fifths acres. We laid it out in parallel strips, which could not be given an equal area, as we had to have as much under cultivation as we possibly could get. But the areas were measured so exactly that a comparison is very easily made. The plots contained: No. I, 21,120 square feet; No. II, 18,720 square feet; No. III (divided in halves—*a* and *b*), 9,120 square feet each; and No. IV, 18,240 square feet.

The *soil* of the tract is, in the main, a decomposed granite, a trifle better in the eastern part. In the northwest corner our red foothill soil adjoins, extending to a line beginning twenty-five feet from the corner, cutting crossways towards the ditch, a line two hundred and fifty feet long, making the base of the cut-off three-cornered piece one hundred and ninety feet. This part, of the red soil, is of a clayey nature, lacking sand until it intermixes with the granite. The tract slopes gently towards the south.

The ground was plowed the regular way, and in good condition when we sowed the *fertilizer* and seed, as follows: No. I, 225 pounds of nitrate of soda; No. II, 400 pounds of bone dust; No. III*a*, without fertilizer; No. III*b*, brand "C" of Mexican Phosphate and Sulphur Company of San Francisco; No. IV, 100 pounds of bone-meal and 100 pounds of nitrate of soda.

The *seed*, four hundred and forty-five pounds of valley-grown barley, was sown immediately after plowing and the distribution of the fertilizers, on January 29th. Considering the poorness of the ground, it must be called a rather thin sowing.

The *rainfall* the grain received during its growth was 18.18 inches, thus distributed: February, 6.55 inches; March, 6.36 inches; April, 4.09 inches, and in May, 1.18 inches.

The *cutting* of the grain took place June 3d; the hay was wetted by a quite unlooked-for rain of 1.27 inches, on June 12th. This, of course, influenced the weight of the hay considerably, as it had to remain exposed to the weather for some time. The quality was little injured, as the succeeding wind and sun cured the hay.

The *weighing* of the crop gave four thousand two hundred and fifteen pounds as the total weight. The single lots turned out as follows: No. I, 943 pounds, or an average of 2,000 pounds per acre; No. II, 1,053 pounds, or 2,500 pounds per acre; No. III*a*, 334 pounds, or 1,500 pounds per acre; No. III*b*, 558 pounds, or 2,750 pounds per acre; No. IV, 1,327 pounds, or 3,000 pounds per acre.

In discussing these results it has to be taken into consideration that the hay was very unclean indeed; as cannot be otherwise expected on a piece of ground taken into cultivation for the first time, and right after clearing. The roots of the brake-fern (*Pteris aquilina*) pulled out while cutting,

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the rake took them along; little roots, sticks and branches, also, got
d in with the hay. I believe that if only the clean hay could have
weighed five hundred pounds would be lacking on the total as stated
e. But this difference would have been of little importance if the
n had been sown earlier than was the case, and hence our figures,
n with such exactness, might just as well be taken as a guiding result
ny one who has to deal with similar conditions.

Table of Results.

Plot.	Area—Square Feet.	Fertilizers Used.	Weight of Hay Crop—Pounds.	Calculated Crop per Acre—Pounds.
.....	21,120	225 lbs. of nitrate soda..	943	2,000
.....	18,720	400 lbs. of bone-meal	1,053	2,500
IIa.....	9,120	No manure	334	1,500
IIb.....	9,120	125 lbs. of "C" fertilizer.	558	2,750
.....	18,240	{100 lbs. of bone-meal. .. {100 lbs. of nitrate soda.	1,327	3,000
lls.....	76,320	.....	4,215	.....

Memorandum of the above Table by E. W. H.

regards, first, the check plot No. III*a* (unmanured), it should be
l that its low product—three fourths of a ton—is quite in accord-
with the reports of the neighbors in cultivating such land. More
a ton per acre is rarely harvested.

will next be noted that the addition of a somewhat excessive dose
rate (given to provide against the chance of washing out by rains)
ased the crop only from three fourths to one ton per acre.

e bone-meal, slow-acting, but supplying both nitrogen and phos-
c acid, increased the product still further by five hundred pounds.
e nitrogenous superphosphate of brand "C," acting more quickly,
ugh used in much smaller quantity, increased the product still
er by two hundred and fifty pounds, being one thousand two hun-
and fifty pounds more than the product of the unmanured plot.

ally, a mixture of two hundred pounds of bone-meal with an
amount of Chile saltpeter, yielded the maximum result of three
and pounds, or double that of the unmanured plot. No. IV, how-
had the advantage of a larger proportion of red soil.

may be regretted that a check experiment with potash fertilizer
ot made at the same time. This will, of course, be done the com-
eason, when the same, and some additional plots, will be again
l, with due regard for what the previous year's fertilization may
left in the soil.

e fact, however, that the joint application of phosphatic and nitrog-
fertilizers at once doubled the product of this soil, agrees per-
with the indications furnished by the chemical analysis; and it
in enough that when hay sells at $20 a ton, the use of the combi-
n used in plot No. IV, costing (when using the perhaps excessive
ing here employed) about $7, will more than pay for itself. With
er seeding and land in better condition, it would doubtless do a
deal more.

e question of the *least amount* of these and other fertilizers pro-
g a profitable result, will form the subject of further trials.

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C. SOUTHERN COAST RANGE STATION.

Two miles north-northeast from Paso Robles, San Luis Obispo County.

By CHARLES H. SHINN.

The station near Paso Robles, on the high ground east of the Salinas River, has been described in the previous report (of 1889). The tract is in the shape of a parallelogram, one thousand seven hundred and twenty feet in depth, and four hundred and twenty feet in width; the latter representing the frontage on the highway. The especial soil advantages of the tract become more evident every year, and although there is more frost than was expected, the range of culture is very extensive. The greater part of the tract is comparatively level, but there is a swale across it, and several lesser depressions, while the land rises towards the rear of the tract. The highest point is where the station buildings are situated.

Fine specimens of the native oaks remain, particularly near the buildings, but it was found necessary to remove seven others in 1890, because they took up too much ground in the orchard and vineyard. Those that remain are typical trees, and should be retained as long as possible. Owing to the nearness of the station to a noted summer resort, Paso Robles, and to the excellence of the country roads, it receives many visitors from all parts of the State.

Several important improvements have been made since the last report. A windmill now takes the place of the horse-power formerly used to raise water, and, contrary to the general opinion, is ample for the present needs of the station, though the horse-power can be used in case of long-continued calms. The worst part of the swale land has been drained, and made fit for orchard or small cultures.

The trees and vines are many of them beginning to bear fruit, and the culture-plots of grains, grasses, clovers, and other crops have attracted much attention. The Foreman, Mr. Cruickshank, is in demand every autumn at the District Fairs of Santa Barbara, San Luis Obispo, and other counties, to which he has taken a large collection of cereals and other station growths. His expenses have been paid from the funds of the respective fairs, and he has thus been able to meet the representative farmers of the entire region. He has not only distributed seed, but, in many cases, he has received valuable seeds and plants for the station. From farmers at Arroyo Grande he secured seventeen varieties of potatoes grown there, some of them seedlings; a new and promising pea from the Azores came through some Portuguese families in Santa Barbara County. The season for the District Fairs comes at a time when the Foreman can easily take a few days from his work, and there is hardly any other way in which the practical results of the experiment station can be brought so directly before the farmers.

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THE ORCHARD.

ɔceeding to a more particular account of the station, the orchard
ıs first attention. At my first visit, in the latter part of 1890, I
much pleased with the appearance of the apples, pears, peaches,
lmonds; the apricots were some of them on unsuitable soil, in the
e of the swale across the tract; some of the figs were where the
appeared to nip them twice a year. The general aspect of the
rd, considering its youth and the variety of soils dealt with, was
ɛtter than one had reason to expect.

ples will be of great commercial value in these Coast Range districts,
ill probably prove better keepers when grown west of the Salinas,
at is called the Adelaide country, where more rainfall and cooler
s are the rule. The Estrella is less of an apple than a peach dis-
from present indications, but apples will undoubtedly thrive there.
n apple trees were set in the orchard this spring (1891), to replace
; the only new variety was Arabskoe. No losses occurred during
from the tree-borer.

rs promise even better than the apples. Some two dozen trees
set last spring, and all are growing. Eight new varieties were
from the Central Station, making the total list something like
ty-five, besides the seedlings and the Japanese stock. Here, as at
ɔothill Station, the pear orchard can be increased to more than a
ed varieties without using more land than at present, as seedlings
orchard form are to be "worked over" as fast as seems desirable.
ccurately labeled pear orchards at all the experiment stations
r to me particularly useful on account of the opportunity they
of correcting and extending local nomenclature, which is much
faulty with pears than with other fruits. The commercial or-
s contain only a few kinds, though many of the finest pears
ı to horticulture have for years been disseminated in family
rds, where their names have been lost. Even at District Fairs I
seen Glout Morçeau labeled Bartlett, and Vicar of Winkfield mis-
l Easter Beurré.

onds continue to surpass all other trees in growth. The wood is
he leaves dark in color and healthy, the bark clean. This seems
ı natural almond country. A few trees planted in the swale, and
ı the season, died in the winter of 1889, and were replaced. Last
four new seedling varieties were obtained—the Silver Shell, the
ı State, the Commercial, and the Ne Plus Ultra—and several others
e budded this summer.

rries.—No new sorts have been planted since 1889, the collection
large enough for the present. The growth is healthy, but not as
as could be wished. No gum disease is yet observed. Some
from gophers were replaced last spring.

icots promise far better results on the granite soil, such as the
enjoys, than on the heavy swale soil. In fact, the apricot, even
robalan stock, "kills out" on the stiff, fine silty soil of the swale.
w on plum stock that survived are very poor. On the lighter,
rained lands, apricot on apricot, and peach on peach, give the
esults. The replanting of last spring was done with reference to
points, and every tree is in fair condition. Luizet and Newcastle
have been added to the varieties represented.

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Peaches and *Nectarines* are extremely successful in both the plots devoted to them, particularly on peach stock, which has made larger growth than the plum stock. A large proportion of the peach and nectarine trees are bearing fruit this year, but it has been "thinned down" to a dozen or less on each tree. So far as I can ascertain two out of three of these bearing trees are on peach stock. Next year fruit may be expected on all or nearly all of the peaches and nectarines. Some of the trees from "dormant buds," often difficult to start, will eventually make as fine trees as any in the orchard.

Plums and *Prunes* show better growth than when last reported upon. This can fairly be attributed to the tile drainage of the swale land. All the gaps caused by dormant buds, late planting, and too wet soil have now been filled, and several new kinds have been added to the orchard. The Japanese plums are some of them bearing this year. Botan is far the most prolific and precocious of these; it deserves a place in every family orchard or garden. The question of stocks will require further observation; there is no appreciable difference between prunes on peach, and prunes on almond or apricot; prunes on Myrobalan seem darker in color of foliage, and slower in growth.

Figs were so badly frosted in the lower portion of the tract, that next year they will be taken up and moved to higher ground. Several new varieties have been planted. The light granitic soil near the buildings suits the figs better, but it is not strong soil, and they grow slowly. The "Bulletin" Smyrna, the Rocardi, and the Adriatic have done rather better than the rest.

Walnuts.—Few trees at the station are more interesting than the English walnuts. All the leading varieties are represented. One tree, a seedling English walnut three years old from the seed-bed, set ten walnuts this summer, a remarkable example of precocity. None of the grafted and named varieties, such as the Præparturiens and Dwarf Prolific, have shown any signs of blossoming as yet; an English walnut ten years old, sent from Berkeley, is likewise without fruit. This early-bearing seedling is, therefore, worth watching hereafter, though this season the nuts were not matured. All the walnuts, most of the chestnuts, and the pecans, are doing fairly, though the latter need more moisture and a stronger soil.

The *Japanese Persimmons* are mostly poor in growth.

Oranges.—These were poor stock originally, and pruned very high, so that the trunks scalded. They are now beginning to root and flourish. They require much water. The leaves are healthy, and the trees were unhurt by the severe frosts of 1889–90 and 1890–91.

Olives.—These are likely to be the pride of the station. Some new olives, among them two of the Berkeley Seedlings, were planted last spring. Nevadillo blanco, Pendulina, Rubra, and a few others blossomed this year.

Small Fruits.—Failure was freely predicted on any or all of the uplands for small fruits grown without irrigation. The station experiments show that thorough cultivation will cause gooseberries, blackberries, and raspberries to grow well and bear largely. A new hybrid between the raspberry and blackberry, obtained at Santa Cruz by the late W. G. Klee, grows very strongly; the canes have red spines and dark leaves, and were well loaded with excellent fruit this season. This berry appears to merit dissemination. The Crandall *blackberry* (unirrigated) is a heavy

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er. The black-cap class of *raspberry* does better than the red. *Cur-* are almost a failure so far, needing more water and shade. Plants e years old have not yet fruited.

Orchard Summary.

e orchard is too young, as yet, to give more than indications of its e. But there are some points of general importance even now. little fruit borne the present season (1891) is of unusual flavor, gh not large. The Japanese plums, for instance, are sweeter and dry than those grown in the Bay counties. They ought, therefore, ip better. The peaches are very high in color, and of fine flavor. the general indications, and from observations made during sev- ourneys over the surrounding country, I think that all the decidu- ruits can be raised without irrigation, in the Paso Robles district, e be taken in the choice of soils. West of the valley of the upper as the apple orchards improve in quality towards the coast; the , prune, and apricot thrive. The almond, in all probability, will be a safe crop in a few localities, owing to the frosts. I have m seen finer three and four-year old plum and pear trees than some irrigated hilltops in this west country, five or six miles from Paso es. East of the upper Salinas, the hill lands more nearly similar to oils of the station tract, were for many years thought worthless, t for scanty pasturage. Even now the old settlers find it hard lieve that careful cultivation will make an orchard and vineyard e there. The vineyard experiment has already led to the planting mmercial vineyards on similar soils both east and west of the y.

VINEYARD.

e vineyard is perhaps the most noticeable part of the grounds, for ines are all well grown, and those of the same variety are remark- uniform in appearance. There are one hundred and ten kinds sented, and this number will be increased to at least one hundred ifty the next season, from vines already in the nursery. The vine- is staked, and shows careful and constant cultivation. At the nt season (1891) nearly every vine is well loaded with grapes. No se whatever has been observed, and very little evil followed the mely hot weather of early summer. Every gap has been filled rooted vines.

THE CEREALS.

e interest in the wheats, barleys, and other cereals grown at the n is increasing, and it is evident that much good has been accom- ed in the way of the distribution of improved varieties. The ving tabulated reports from the Foreman, Mr. R. D. Cruickshank, serve to show the range of these cultures:

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Report on Cereals Grown on Light Soil; Season of 1890–91.

By R. D. CRUICKSHANK.

WHEATS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
Volo	Oct. 10	May 3	June 17	Does well here; a very large, solid-stemmed variety.
Black Centennial	Oct. 20	Apr. 29	June 20	Does well; a very handsome wheat; grows tall; stools out well; extra fine variety.
Russian Bearded (Hessian-fly proof)	Oct. 10	May 5	June 17	Good crop.
Palestine	Oct. 10	May 7	June 13	Good crop; very much bearded; good berry.
California Spring	Oct. 10	May 1	June 24	Crop regular; plentiful; fine heads and large berry; extra fine variety.
Royal Australian	Oct. 10	May 1	June 20	Stands at the very head of the list as a milling wheat; does well here.
Petali	Oct. 10	May 4	June 12	Fine heads; very much bearded; does well here.
Pringle's Defiance	Oct. 10	Apr. 27	June 17	Fine long heads; crop uneven; would make good hay.
Nicaragua	Oct. 10	May 1	June 15	Crop good; bearded; not recommended here.
Frankenstein	Oct. 10	May 5	June 15	Grew well; long heads; but not a heavy yield.
Victoria	Oct. 10	May 4	June 18	Partly damaged by water lying and soil subsiding; test not fair.
Taganrog	Oct. 10	Apr. 26	June 15	Did well; a showy wheat of the solid-stemmed style.
Red Club, or Hedgehog	Oct. 10	May 2	June 19	Did well; a curiosity; not heavy crop; birds fond of it; much eaten by them.
Imperial	Oct. 10	May 3	June 17	Crop good; showy.
Champlain	Oct. 11	May 9	June 20	Not adapted for grain here, but would make good hay.
Ghurka, or Odessa	Oct. 11	May 4	June 19	Grew well; bearded; not recommended here.
Harris from Jasper	Oct. 11	May 3	June 16	Grew well; stool enormous; better for hay than grain.
Blue Glass	Oct. 11	Apr. 29	June 19	Grew well; large heads; peculiar on account of color.
Missoyen	Oct. 11	May 1	June 20	Very fine crop; solid-stemmed variety.
Greek Atlanti	Oct. 11	May 2	June 18	Crop splendid; heads large; straw strong; stem solid.
Polish, or Diamond	Oct. 11	Apr. 29	June 13	Did well; a curious variety, called wild-goose wheat, used for vermicelli.
Indian, three months	Oct. 15	Apr. 10	June 13	Sonora type; did well and made fine hay.
Arizona Indian Seed Wheat	Oct. 15	Apr. 6	June 13	Did very well; Sonora type; if sown thick, makes good hay.
Snowflake	Oct. 15	May 8	June 20	A very showy variety; did well; would make fine hay.
Tunisian	Oct. 15	Apr. 28	June 20	Did well; solid-stemmed, tall.
Archer's Prolific	Oct. 15	May 5	June 13	All that could be desired; type same as Propo; heavy yield.
Whittington	Oct. 15	May 2	June 13	Good crop; beardless; probably too soft.
Genoese	Oct. 15	May 5	June 13	A fine crop; a first rate red wheat.
Pringle's Best	Oct. 15	May 9	June 13	Not valuable for grain; would make good hay.
Yellow Noé	Oct. 15	May 12	June 18	Grew well; leafy straw; make fine fodder.
Indian Winter	Oct. 15	May 5	June 20	Grew well; stooled out very fine; small grain; extra fine for hay.
Fern, or April	Oct. 15	May 6	June 29	Heavy crop; bearded; not recommended.

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WHEATS—Continued.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
n	Oct. 15	May 6	June 13	Grew well, but too strawy.
e	Oct. 15	May 8	June 13	Grew well; club type; birds partial to it; good for hay.
gian	Oct. 15	May 13	June 15	Grew well; highly recommended for fodder; immense stool.
ed Circassian	Oct. 15	May 12	June 13	Crop heavy; liable to shrink in berry.
an	Oct. 15	May 12	June 20	Splendid crop. A curiosity by having seven heads; not very good for milling.
Red Winter	Oct. 15	May 9	June 13	Seed was poor; but if under favorable conditions would make good hay.
Red Indian	Oct. 15	May 7	June 19	Crop regular; beardless.
	Oct. 15	May 5	June 13	Did well; not heavy, but very regular; beardless.
nora	Oct. 15	May 3	June 13	Very fine regular crop. If sown thick would make the very finest hay. It does well in hot upland.
arded	Oct. 10	May 3	June 8	Did well, but birds destroyed before ripe.

BARLEYS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
aya	Oct. 15	Apr. 6	June 1	Remarkably heavy crop.
Blue Naked	Oct. 10	Apr. 12	June 8	Good crop; misnamed—not blue.
's Pedigree	Oct. 15	Apr. 28	June 8	Extra fine crop; Chevalier type.
urian	Oct. 11	Apr. 6	May 23	The earliest; subject to breaking down.
	Oct. 11	Apr. 6	June 1	Did very well.
six-rowed	Oct. 15	Apr. 25	June 8	Did well.
al	Oct. 10	Apr. 15	June 8	Good crop.
	Oct. 10	Apr. 19	June 8	Did well; very pretty.
ier	Oct. 15	Apr. 20	June 8	Did well, but better on adobe.
ed	Oct. 11	Apr. 12	June 1	Fine crop.
	Oct. 11	Apr. 13	June 1	Did well; liable to get broken by wind.
two-rowed	Oct. 15	Apr. 19	June 8	Did well.
s Prolific	Oct. 15	Apr. 10	June 8	Heavy crop; Chevalier type.
Naked, two-				
d	Oct. 11	Apr. 5	June 1	A very heavy crop.
	Oct. 11	Apr. 10	June 1	Did well; good for hay.
r "Sprat"	Oct. 15	May 5	June 11	Heavy crop; great curiosity; very contorted.
ment of Agri-				
re No. 6	Oct. 15	Apr. 10	June 8	A new barley received in 1890 from Department of Agriculture, Washington. Excellent heavy crop.

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OATS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
Scotch Hopetown	Oct. 10	May 4	June 17	Can be highly recommend this section for milling.
Gray oats from Houdan	Oct. 10	May 5	June 25	No use here, too late to co maturity; has been the three years.
Early oats from Georgia	Oct. 10	May 5	June 25	No use; too late in ripening
Bald oats	Oct. 10	May 7	June 16	This oat does well; would fine oat hay; it has no and plenty of leaf.
Early August	Oct. 15	May 9	June 25	Good style, and does fairly
Surprise	Oct. 15	May 10	June 15	Does well, and can be mended.
Black Tartar	Oct. 15	May 10	June 25	Does not do well; all straw.
White Wonder	Oct. 15	May 6	June 25	A very prolific oat; does came from the Departme Agriculture, 1890.
E. K. Carr, Texas	Oct. 11	May 6	June 8	Suitable for this section; ha well three years here.
Canadian	Oct. 10	May 2	June 26	Not adapted for this se ripens imperfectly.

RYES.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
Perennial Saxon	Oct. 10	Apr. 28	June 25	Did extra well.
St. John's Day	Oct. 10	May 5	June 27	Made very handsome recommended.
Swedish Sand	Oct. 10	Apr. 28	June 25	Made very large stool; fine.
Excelsior Winter	Oct. 10	May 5	June 20	Did well; fine, even crop.
Spanish Double-bearing	Oct. 10	May 5	June 25	Did splendidly; made ver stools.

SPELTS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
Common White-Bearded	Oct. 10	May 5	June 26	Did extra well.
Red Emmer	Oct. 15	May 12	June 26	Did the poorest of all the tried.
White Silesian	Oct. 10	May 12	June 26	Medium crop; did fairly we
White Emmer	Oct. 15	May 9	June 28	Grew well, but points blaste

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Report on Cereals Grown on Adobe Soil; Season of 1890–91.

WHEATS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
en	Dec. 26	May 2	June 22	Heavier heads than on the light soil; very fine, solid-stemmed variety.
Atlanti	Dec. 26	May 5	June 20	Splendid crop; noble heads.
id, or Polish	Dec. 26	May 10	June 18	Crop splendid; evidently does to perfection on adobe; tapioca variety.
ne	Dec. 26	May 8	June 15	Did not do so well as on light soil.
Club	Dec. 26	May 9	June 25	Very fine; yields well.
ial	Dec. 26	May 15	June 24	Strong, handsome variety; quality fine.
's Pedigree te Victoria)	Dec. 26	May 11	June 20	Very fine.
Red Winter	Dec. 26	May 9	June 19	Seed was old; does not look promising.
ia Spring	Dec. 27	May 3	June 25	One of the finest; can be highly recommended for trial.
Bearded (Hes- ly proof)	Dec. 27	May 5	June 20	Fine crop; does well here.
	Dec. 27	May 9	June 15	All that could be desired; in great favor about here.
ass	Dec. 27	May 9	June 20	Fine crop; peculiar metallic color.
nstein	Dec. 27	May 6	June 25	Not very good; too light crop.
r April	Dec. 29	May 12	June 13	Did well, but a little irregular.
	Dec. 29	May 12	June 13	No good on adobe.
	Dec. 29	May 13	June 15	Did well.
g	Dec. 29	May 15	June 18	Did well.
eil	Dec. 29	May 9	June 21	Fine, even crop; long heads.
gton	Dec. 29	May 9	June 20	Did very well.
n	Dec. 29	May 6	June 19	The poorest of any.

BARLEYS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
s Pedigree of alier.	Dec. 26	April 28	June 9	A very fine barley; an improvement on the ordinary Chevalier.
lack, two-rowed	Dec. 26	April 27	June 9	Very fine, heavy crop.
	Dec. 26	April 19	June 13	A very fine crop.
two-rowed	Dec. 26	April 15	June 14	Fine crop; regular.
Prolific	Dec. 27	April 10	June 13	Did extra well; straw short.
lack, six-rowed	Dec. 27	April 25	June 9	A very heavy crop.
	Dec. 27	April 6	June 9	A very fine crop.
Naked, two- d	Dec. 27	April 5	May 12	A heavy yield; grain large.
nent of Agri- re No. 2	Dec. 27	April 6	June 18	Did first rate.
ed (Brenner)	Dec. 27	April 7	June 18	Did very well.
y Hybrid	Dec. 27	April 5	June 9	Does well; a fine variety for straw.
ed (Winter)	Dec. 29	April 12	June 15	Did first rate.
Vaked	Dec. 29	April 12	June 9	Did well; heavy yield.
nent of Con- ine No. 2	Dec. 29	April 12	June 13	Did first rate; heavy crop.
ya	Dec. 29	April 10	June 15	Finest crop of all.
nent of Agri- re	Dec. 29	April 10	June 15	Did very well; a good barley.
er	Dec. 29	April 5	June 13	Did well; heavy crop.

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OATS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
Bald	Dec. 29	May 10	June 17	Did very well.
Gray oats from Houdan	Dec. 29	May 3	June 20	Not good.
Canadian	Dec. 29	May 2	June 20	Of no use.

SPELTS.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
Black Emmer	Dec. 27	May 6	June 20	Did not fill well.
Red Emmer	Dec. 27	May 5	June 20	Not large head; did fairly.
White Silesian	Dec. 29	May 10	June 21	Light crop.
White Emmer	Dec. 29	May 8	June 23	Did very well.

RYES.

Varieties.	Sown.	Bloomed.	Cut.	Remarks.
St. John's Day	Dec. 29	April 5	June 25	Did very finely.
Excelsior Winter	Dec. 29	April 6	June 25	Did fairly well.
Perennial Saxon	Dec. 29	April 7	June 26	Even crop.

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D. SAN JOAQUIN VALLEY STATION.

One mile southeast of Tulare City, Tulare County.

By CHARLES H. SHINN.

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ne of the stations have greater difficulties to contend with than the n near Tulare City, and none are of more interest, present and pros- e. The soil chosen is considered very poor by some farmers, and e results of cultivation have been surprisingly good. The alkali ferent grades that exists in spots on the tract offers every oppor- for experiments with new cultures, and with systems of reclama- It is more and more evident that while this station will never nt the uniform excellence of the Pomona or the Amador stations, it of the most important experiment stations in the United States, se it is representative of an immense area of soils at present util- ut little, or not at all—soils, too, that possess all the elements of life, and are of very great intrinsic value. The site was chosen count of the special advantages it offered for experimenting with soils. The first task is to determine what plants thrive on alkali; to experiment with methods of modifying or reclaiming such soils.

THE ORCHARD.

e general appearance of the orchard is improving. Many dormant failed in 1888–89 and were replanted; others on bad alkali have to some extent and were reset on different stock. As a conse- e the orchard is extremely uneven, and will be so for several years r. Last winter (1890–91) there were less than fifty trees reset, hose only in small spots of strong alkali. The total planting of st season was about one hundred fruit trees, including many new ies, a number of olives and figs, and the Persian date palms, else- e described.

ricots have made a fine and sturdy growth of from three to six feet. e on light alkali gain more slowly, but are healthy, particularly the ngs. Those on strong alkali died, and have been reset with a barrow-load of sand and a dressing of plaster about them. The ts are near to the main street, at the east of the station, and a row ves is planted along the fence. Seedling palms are outside, along ad.

ches, which come next to the apricots, have made a still better h, and a little fruit was borne this season. The alkali affected in much the same way as the apricots. The peach orchard es two spots of alkali, one of very strong black, the other lighter, e main avenue. A wheelbarrow-load of sand gives temporary aid, nder-drainage and leaching the surface, together with a dressing aster, are necessary to remove the surplus alkali. The surface soil aped away and the sand and plaster put about the roots. Peach

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on Myrobalan stock, though of poor growth, resists the alkali b
than peach stock—in twelve cases of Myrobalan stock, all surv
except one. Other plum stocks, in as great variety as possible, o
to be tested on such soils.

Plums generally have done best on the sandy soil. Some of
strongest alkali has been too much for some varieties of plums, b
second setting there appears better. Yellow Gage, Imperial, Pr
Englebert, McLaughlin, Bryanstone Gage, Ickworth Imperatrice, E
Golden Drop, and Prunus Simoni, have stood the alkali very
Orange plum and Bleecker's Gage have survived some of the
strongest black alkali on the tract, but Masu, Botankio, Kelsey,
bank, and the Long-fruited Japan, do not stand it nearly as well as
European plums. The German prunes are in two different spot
alkali, and do fairly well in both; Prune d'Agen has failed in
stronger alkali. Some dormant plum buds in alkali did but po
Robe de Sergent prune stands the alkali, and so does the Datt
Hongrie. One of two Wangenheims on alkali soil is doing well.
conclusion from two years' observations is that the Japanese pl
are most sensitive to alkali; that several of the *Prunus* resist it b
than other European plums do; and that *Prunus Simoni* is part
larly hardy.

Nectarines.—A bad record; worse than that of any other fruit. H
wick stands light alkali, but this, as well as all other kinds, pu
stronger alkali, succumbs more rapidly than the apricot or pe
Eleven out of twenty-five trees set in 1888–89 had succumbed to al
before the spring of 1891.

Apples.—In some cases more than a fair growth, but on rather l
apple soil, and usually of slow growth. There is little alkali in
apple tract; wherever it appears the effect is immediately seen.
bridge has made some growth in alkali, where the Lady apple
Huntsman died.

Almonds.—The strongest alkali in the almond orchard was n
planted, as it was useless to do so. Almond trees grown in the N
and Sonoma Valleys made a very poor start, and soon failed; stock
San José, Stockton, and the home station did much better. The
fornia seedling varieties make a far stronger growth than the Langue

Pears.—Strong alkali is on one end of the tract, making an excel
test. Mount Vernon, Onondaga, Jaminette, Doyenne d'Alençon, Ba
Pound, Glout Morçeau, Louise Bonne de Jersey, Flemish Beauty, Es
Beurré, Lawrence, and some other varieties are doing well in alkali
B. S. Fox failed there. The Chinese type of pear seems particul
well adapted to the climate. Japanese seedlings promise to be of v
for stocks.

Olives.—It is a very gratifying fact that the olive grows well in
where the peach, apricot, almond, and nectarine are destroyed by
black alkali. Trees planted in 1889–90 and others in 1890–91 are a
successful. The best growth is on the light alkali soils; the light sa
soil, free from alkali, is but poorly adapted to the olive. The com
Mission olive does well in alkali soil, near San Francisco Bay, and l
trees are growing in such soil in Santa Clara County. At the sta
there is little difference yet between varieties, excepting that Neva
blanco and Pendulina are doing especially well.

Figs.—Some of the fig trees at the station are superior in appear

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se at Amador or Paso Robles. This refers only to those on the ary soils; a few on strong alkali have perished, but were replaced, extra precautions, using plaster as a dressing. Angelique, Califor- lack, Raby Castle, and Glossale are the failures so far. Smyrna White Adriatic promise unusually well.

er Plants.—Among the trees and shrubs well adapted to the region ne carob, the Kai apple, the camphor, and the common purple . The oranges made a much better growth this season (1891). our Florida stock started slowly, the roots being poor. The dwarf ese kinds promise entire success. Among the walnuts the Cali- seedling soft-shell variety has made the best growth. Chestnuts from the heat, even if protected. *Ficus Australis* and *F. macro-* both thrive with little care. All the mulberries are entirely at in the district. Bamboos need care to start, but do well when ished. The basket willows are grown with the greatest ease, if ed with plenty of water, and the farmers are beginning to plant more extensively. The California maple does but poorly, but the lm can be recommended.

THE CEREALS.

eat.—The problem in wheat-growing at all the stations has been oduce satisfactory results at small expense, and under practical ions. Every farmer who visited the Tulare station expressed his se at the crops obtained without irrigation. All the wheats were d in drills six inches apart. The wheat and barley plots were nt; nearly one half of the soil devoted to these two cereals was ly alkaline. The ground was deeply plowed and cross-plowed, ulverized almost to dust. The wheat was sowed before the rains . The seed was divided into parcels, and soaked for from half a five days in bluestone, some farmers having claimed that long g spoils the germs; but all the parcels of seeds grew equally well. nd a half ounces were sown to each one hundred and forty-five drill. The wheats began to ripen in the latter part of May, and ued into June. Petali, Diamond, Blue Glass, and Archer's were the earliest.

following table shows the yield, and the soils on which some g varieties of wheat were planted; each kind occupying one hun- nd forty-five feet of drill:

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Table Showing Yield of Wheat, and Character of Soil.

NAME OF VARIETY.	Yield of 145 Feet of Drill—Pounds.	S
Arizona	23.25	..Hal
Archer's Prolific	33.50	..Hal
White Club	12.50	...All
California Spring	46.00	..Hal
Chile	30.75	..Hal
Greek Atlanti	32.50	..San
Pringle's Best	25.25	..Hal
Pringle's Defiance	19.25	..Hal
Palestine	23.25	..Hal
Petali	25.00	..Hal
Thuringian	13.50	..Hal
Whittington	37.50	..Hal
White Banat	9.25	..Hal
Michigan	19.75	.....
Missoyen	22.00	..Hal
Egyptian	13.25	..Hal
Royal Australian	32.00	..Hal
Red-bearded Russian	21.00	..Hal
Sonora	12.50	..Hal
Volo	27.50	..Hal
Yellow Noé	16.75	..Hal

The above named wheats, in most cases, yielded rather more than as much on the good soil as on the alkali. The Russian (red-bea only yielded one third as much on the alkali as on the good so Sonora and Yellow Noé, both light crops, yielded four fifths as Many other wheats besides those tabulated were tested with results. Clawson, Black Centennial, Champlain, Frankenstein, F Snowflake, and Odessa may be classed as entire failures on alkali The Chile stands drought well; so do Archer's Prolific, Michigan Palestine. Among the kinds that lodge badly are the improved C sian, Nonette Lausanne, and Nicaragua.

Barleys.—The best barley tested for hay was the Berkeley H sown broadcast, 288 pounds of seed to the acre. Of the drilled b the Blue yielded 21.5 pounds per drill of one hundred and fort feet. Carter's Prolific yielded 15.5 pounds, Chevalier yielded 19 po and the Early Black the same. The most prolific barley was the alaya, which yielded 48 pounds. It will be noted that this is one best bearing kinds at the other stations also; it can be confi recommended. Another excellent sort is the Italian, which yield pounds. The Manchurian yielded 28 pounds. Some of the other were as follows: Hallett's Pedigree, 13 pounds; Brenner, 5.5 po Nepaul, 21 pounds.

Rye.—The Excelsior, in drills of one hundred and forty-five f length, yielded 12 pounds; the Swedish, 7 pounds; St. John's Day pounds; the Saxon Perennial, 19 pounds. The Spanish was the yielding 22.25 pounds. All these were sown in strong alkali soil.

Oats.—The oats were sown too late, but the following did fairly Canadian, Gray Oats, Scotch Hopeton, oats from E. K. Carr of Early Oats from Georgia, Surprise, White Bolognese, Early August, Tartary. All of these were sown in alkali soil. The best varieties this season (1891) were: Surprise, Winter Bolognese, Early Black the Gray Oats from Houdan.

Spelts.—White Silesian (in the usual drill) gave 9.5 pounds;

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ed gave 8.25 pounds; the common white-bearded gave 5.5 pounds. he spelts were on alkali soil. Spelt is a mountain grain, chiefly where wheat does not thrive, and it is but poorly adapted to the San Joaquin region.

GRASSES AND CLOVERS.

e Hungarian brome grass stands drought well, and is recommended. ier's brome is rather better than the Hungarian. The Australian rass is another excellent sort. The climate is too dry for timothy. oft Meadow grass does fairly in the season, but needs a great deal ter. Italian ray grass, after three years' trial, ranks at the head e list. *Agropyrum glaucum* ("blue stem") stands drought, and ies deeply rooted. The Red Fescue does but poorly. The red white clovers are excellent the first part of the year; need much . The yellow bird's-foot clover is much the same after two seasons' but stands drought better than red and white clovers. *Anthyllis aria* is a failure. *Hedysarum coronarium* grows well on alkali soil; d three feet high this season, and yielded heavily. The Bokhara thrives with little or no water, striking deep roots, and growing eet high.

e grasses and clovers were not watered at all until July, and then ttle. They were watered again in September. The effort has been w them, as far as possible, without irrigation. Several other for- ants have proved of value; the sainfoin (esparcette) is one of the

COTTON.

periments show that the future of cotton culture is highly promis- Two varieties were planted, "Big Boll" and "Poor Man's Relief," lls, March seventeenth. They yielded, with little irrigation, at te of a bale (four hundred pounds) to the acre. This was on light ome of it alkali.

OTHER CULTURES.

nie is an entire success, even on light alkali soils, and has been dis- ed to many farmers. Six kinds of flax were sown, but they grew about a foot high; it is evidently not adapted to the soil and te. Jute was sown, but the frosts of the following winter killed it. -beets of the best varieties have done fairly on the sandy soils, but on the alkali. It is hardly the place for beet culture, though is plenty of good soil for this crop in the region. The mangolds ter than the sugar-beets. Twelve varieties of sorghum are grown sed for fodder; they produce fairly on the alkali—perhaps half ch as on the ordinary soil. Japanese buckwheat is the best of uckwheats, but the climate is too hot for this crop. The Chick nd the Algerian pea grow well.

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E. SOUTH CALIFORNIA STATION

Near Pomona, Los Angeles County.

By CHARLES H. SHINN.

Since the last report was issued a new station has been establi
that of South California, in the Chino Valley, near the town of P
This valley is one of the best known localities in the State, and po
many and especial advantages for an experiment station. The
which led to the selection of the place were amply set forth in
lowing extract from Prof. E. W. Hilgard's letter to the Board of R

BERKELEY, July 1

Regent J. F. HOUGHTON, *Chairman Committee on Experiment Stations:*

DEAR SIR: Pursuant to the decision of the Regents locating the station for So
fornia near Pomona, I have at once revisited that locality in order to expedite
as much as possible, and insure the beginning of operations for the coming seas
in order to determine which of the alternative offers made of tracts of land s
accepted.

I returned last evening, and as the result of my further investigation, would rec
the acceptance by the committee of the offers made by Mr. Richard Gird, of "thi
of land described in the first offer" (located on Sec. 34, T. 1 S., R. 8 W.), "with a
tionate amount of water, and ten acres of the naturally moist land describe
second proposition herewith."

From a detailed inspection, I find that the thirty-acre tract will have about fi
of the reddish mesa soil that is deemed specially appropriate for citrus fruits,
sixth of the gray gravelly soil that characterizes the "washes" of the Sierra Ma
order to include this large proportion of the mesa soil proper, it will be necessar
the tract somewhat "L" shape.

For the location of the detached tract of ten acres, I explored in detail the
limit of the moist lands, in order to obtain it as near the other tract as possible
detracting from its special character. I found this realized in a ten-acre tract
center of Sec. 10, T. 2 S., therefore a trifle over two miles due south of the ma
from which an avenue runs directly to it, minimizing the distance to be traveled b

While this adoption of the plan of two distinct tracts will increase somew
expense and trouble of the station work, it seems difficult in this case to do j
the region intended to be represented by the station, without such segregati
dark loam soil of the moist lands is extensively represented not only in the inte
leys, but also along the coast, and its capabilities should be thoroughly tested.
acre tract is sufficiently large to permit us the covering of expenses, in part, by the
of hay for the team, as the land is profusely productive, and four out of the
would probably suffice for the ten tons of hay needed. I therefore recommend th
ance of these two tracts.

Work at the Station Begun.—The home tract chosen, on whi
buildings are placed, is situated three miles southeast of Pomona
whole region about it is rapidly developing, and will soon be a c
ous garden and orchard. Sugar-beet culture is being carried on
vicinity by Mr. Richard Gird and others, on the largest scale kn
California. Large orchards of figs, oranges, olives, prunes, walnu
other fruits are being planted, and the nurseries already estal
serve to make the valley a notable center for horticultural indust

Late in November, 1890, the University assumed charge of the s
sending Mr. K. McLennan, formerly Foreman of the Central Stat
lay out the grounds and begin work there. The building was not

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upancy, and the Foreman had to live at Chino for several weeks
his arrival. Mr. Gird, the donor of the station, kindly gave the
a horse and outfit to the Foreman for two months, so that he
drive to and from the town. Two large and strong work horses
ought, and the work of clearing the ground of weeds and brush,
veling it fit for planting and irrigation, was commenced by the
of December. A third horse was bought in April.

r Supply.—When the station was established, an ample supply
r was delivered at the highest corner of the tract, through a three-
ment pipe laid from Mr. Gird's main reservoir, one mile distant.
to various leaks and breaks during the winter, it was sometimes
t to obtain water, but the flow is now steady and constant. The
s delivered at the northeast corner of the station grounds. Here
nch stand-pipe of cement raises the water four feet. Some three
d and twenty-five feet of inch pipe (iron) is used to conduct
to the barn and house. The pressure is very weak, but it is
ul whether the cement pipe would stand a much higher stand-
It will be necessary to build a permanent reservoir of cement in
o utilize the supply of water, which is ample for all purposes if
y saved. Otherwise, as the demands of the growing population
e, it will probably be found that the station can only have water
ain days.

aration of the Tract.—The whole thirty acres was first broken
twelve-inch plow, "driven to the beam," and was afterwards
lowed. Clearing, plowing, grading, and laying out the roads and
ccupied the entire time of the Foreman with two workmen and
ams, from early in December to the middle of February. The
has been well done and insures easy irrigation so soon as a
ir is built. February 19, 1891, the shipments of trees and plants
o arrive at the station. But the great rainstorm of February
-first and twenty-second flooded a portion of the valley, and
gravel and mud over a part of the tract, destroying much of the
lready done. An extra month of labor was required to prepare
und for the orchard, and the whole tract was again plowed and
lowed as soon as the weather would permit. This particular
" or overflow, occurs at long intervals, but now has been guarded
, in a measure at least, by the people of the region, and is never
nt to injure established crops.

ing, Farm Buildings, etc.—It was necessary to protect the orchard
bbits. Nearly four thousand feet of woven wire fence was put
t summer, inclosing eighteen acres of the tract, and leaving
acres unfenced. Cattle are at large on the bottoms, and it will
isable to strengthen the fence with a six-inch board. In a few
o fencing will be necessary, excepting around the small culture
nd nursery, for the whole valley is rapidly coming under cultiva-

stable has a hay-loft, work-room, and wagon-shed, with a yard
rcise behind the building, much like the other station, except
ss space is given for the yard. The main station building is simi-
he one at the Tulare station, described in previous reports, and
to be adapted to the work required. It was built according to
nd specifications furnished by the University.

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THE ORCHARD.

Owing chiefly to the delays caused by the overflow, planting wa
begun till March thirtieth, and was completed by the middle of
fully a month later than is desirable in the Pomona region, particu
for deciduous trees. The main orchard now contains seven hu
and thirty-eight trees and three hundred and sixty-five varieties
lies east and south of the house. The square system is adopte
planting. The trees are set twenty-four feet apart each way, m
seventy-six trees to the acre, and allowing an opportunity for
dwarf trees, small fruits, and miscellaneous cultures between the
for a few years at least. The trees have been irrigated six times,
tree receiving six or eight gallons at a time. A strip of about four
of easily-worked and excellent land is left north of the orchard, n
the road, for small cultures and nursery. This strip is one hu
and fifty feet wide at the house, and sixty-eight feet wide at the we
end.

Olives.—There are now twenty-one varieties established here, nin
of which were two and three years old, grafted. These were received
the California Nursery Company, at Niles. One Mission, one yea
grown from small cutting, was donated by A. P. Simpson, Pomona.
Empeltres, two years old, also grown from small cuttings, were do
by Alfred Wright, Pomona. All the olives are making good gr
and are doing as well as could be expected the first season.

Citrus Fruits.—Three varieties of lemon were planted. They
two years old from the bud, and were purchased in Pomona. They
a remarkably strong growth for the first year.

Of citron three varieties are planted, all two years old, budde
orange stock. These were received from F. A. Kimball, of National
and arrived in poor condition. Two of them have made a feeble
The names of these new citrons are Sorrento, Calabria, and Amalf

Eight varieties of oranges were received from Twogood & Cutt
Riverside. These were three years old, and budded on sour
Another lot of oranges were received from Mr. Howland, Pomona,
varieties, two and three years old, and budded on sweet stock. A
oranges show a remarkably vigorous growth, and we cannot yet se
marked difference between the growth of the sweet and the sour st

Almonds.—Fourteen varieties were received from the California
ery Company. They made a very good growth; there are but two
ward ones in the lot.

Cherries.—Ten varieties were planted, all one year old. They a
living and doing well.

Peaches.—Thirty-seven varieties are budded on peach stock.
teen varieties are on Myrobalan stock. The latter started earlier
those budded on the peach stock, and made a very good growth.
the peaches have done admirably.

Nectarines.—Received from the Central Station nurseries,
varieties, one year old, budded on peach stock. They were strong
and have made a splendid growth.

Apricots.—Eleven varieties, one year old, budded on apricot
were received from Niles. All the apricots made a large, strong gr
From the Central Station, five varieties were sent, one year old, bu
on peach stock.

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ms and Prunes.—Five varieties of plums were planted, one year chiefly on Myrobalan stock. Some of them made a growth of to four feet. Eighteen varieties of prunes were planted, mostly Myrobalan stock, though other stocks are represented. Eight ties of Japanese plums are also planted.

rs and Apples.—Twenty-five varieties of pears, one year old, were nt. Forty-five varieties were sent from the Central Station. The suffered more from the heat, and made less growth, than any other ious trees. The apples also suffered heavily during a hot spell, h they made a good start. Forty-six varieties, largely southern were planted here.

s.—Some of the trees sent were too large. The small trees from entral Station did much better than those bought outside. Mr. nnan, the Foreman, states that his experience with figs is especially able to small trees, not branched, and of from say one to two feet ight. They start quicker and grow faster than larger trees. ty-two varieties were planted.

dition of Orchard.—At the present time the orchard shows careful ing, and looks well. It will need more water next summer. Some have died, owing to lateness of planting, but the loss is not more twenty-five in the whole orchard, and these of varieties easily eed. The peaches, plums, prunes, and apricots present a most satis- y appearance. So do the citrus fruits, olives, and figs. Some ts, one a new variety, donated by J. S. Calkins of Pomona, and other Japanese fruits, are doing well.

THE VINEYARD.

enty-five varieties of grapes have been planted in the nursery, and spring, together with many additional varieties, will be planted in ar vineyard form. Among these will be the new Persian grapes ly sent out by the United States Department of Agriculture, and lately imported from Italy.

DATE PALMS.

e named varieties, mostly from Persia, imported by the United Department of Agriculture, are now planted near the house, and n time, form one of the most prominent features of the station. ast added to the collection is the famous Fard date. Seedling and some other palms have been planted, but none of the ordinary es generally used for ornament. The Persian dates have all made growth.

NOTES ON OTHER PLANTS.

e camphor tree did poorly, suffering extremely from the heat. So he *Cryptomeria Japonica* (Japan cedar). The strawberry tree *tus unedo*) is also a slow grower here, and is probably not suited climate. *Magnolia grandiflora* and *Edwardsia grandiflora* grow y; the former scorches in the sun, and so does the garden laurustinus *rnum tinus*). Fuchsias suffer greatly from the winds. Heliotropes chrysanthemums do well in the garden, when sheltered. *Pitto- m odoratum* does fairly well so far. The acacias thrive. *Ficus*

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macrophylla made a good growth, but may suffer somewhat in wi
Fabiana imbricata is another of the successes. *Metrosideros buxifol*
also a fine grower here. The best of the guavas so far is the *pomife*
the *Cattleyanum* seems to start but slowly. Among other trees
plants that seem to suit the place particularly, the Foreman report
Mediterranean heath, the *Capparis spinosa*, or caper bush, and the c
(*Ceratonia siliqua*).

The Chinese tea plants were small when planted, and have ma
very slight growth. The bamboos were nearly as bad. The clima
hot for camellias. New Zealand flax has hardly started, but wi
better when it has more water. The *Citrus trifoliata* appears to be ex
adapted to the region.

The experiments of the past summer in ornamentals were exte
by gifts of plants from gentlemen in the vicinity. A complete li
these donations follows. Japanese persimmons, pomegranates,
varieties of eucalyptus, several *Passifloras*, and a large number of u
and interesting plants are still in pots and boxes, or in nursery row
next season's planting.

PLANTS GIVEN TO THE STATION.

From J. S. Calkins, Pomona: Two fuchsias, two camphors
Washingtonia filifera palms, two laurustinus, two *Cupressus macroc*
two *Cupressus pyramidalis*, two *Magnolia grandiflora*, two tea plants
camellias (seedlings), two *Acacia melanoxylon*, two *Melia Azedarach*
chestnuts, two *Grevillea robusta*, and garden plants in variety.

SORGHUMS.

A very choice collection of sorghums obtained from various so
was tested, more for fodder and domestic uses than for sugar. T
is no reason to believe that any better sugar plant than the beet
be found for the region, though quite a number of Californians are
ing sorghum culture for sugar. But the chief value of the sorgh
lies in the fact that they yield a very large amount of animal
Twelve varieties were tested this year at the station. The New Or
bloomed September 5th. It grew six and a half feet high and
stocky. Whiting's sorghum bloomed August 18th and proved
earliest of all. Enyama failed, the seed being old; it is one of the
African sorts. The Duchess Hybrid bloomed September 1st and
seven feet high; stalks unusually sweet. "No. 42" from the U
States Department of Agriculture, grew ten feet high and bloomed
but the stocks were dry, pithy, and of little or no value. The S
African grew eight feet high and was of fair quality. Early Ar
nine feet high, bloomed August 30th. Link's Hybrid bloomed Sep
ber 15th, reached a height of ten and a half feet, with very stout
strong canes. Folger's Early bloomed September 10th and was
and a half feet high. Colman's Cane, from Missouri, grew eleve
high, and bloomed September 28th.

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GRAPES PLANTED AT THE POMONA STATION.

bernet Sauvignon.
bernet franc.
inturier mâle.
eunier.
rine.
tite Syrah.
ondeuse.
stardo.
nsaut.
oussard.
rignane.
tit Bouschet.
icante Bouschet.
amon.
raire de l'Adhui.
taro.
enache.
ourastel.
rsanne.
ni blanc.
narda.
eatico.
lvasia bianca.
ourisco preto.
nta de Madeira.
nta Amarella.
nto Cão.
al de Madeira.
lomino.
dro Jimenes.
rdelho.
est's White Prolific.
meria.
oscato di Alessandria.
rbarossa.
ompson's Seedless.
Semillon.
Folle blanche.
Chauché gris.
Verdal.
Burger.
Franken Riesling.
Orleans Reisling.
Gewürz Traminer.
Lagrain.
Bakator rouge.
Slankamenka.
Green Hungarian.
Wälsch Riesling.
Kadarka.
Marzemino.
Blue Portuguese.
Gross blaue.
Refosco.
Nebbiolo fino.
Barbera.
Purple Cornichon.
Black Ferrara.
Black Muscat.
Pizzutello.
Isabella regia.
Diana.
Diamond (white grape).
Martha.
Lenoir.
Cunningham.
Syrian (Palestine).
Luglienga.
Sabalkansky.
Gros Colman.
Sultana (round-berried).

e above plantation has been commenced on the plan of represent-ll the classes of grapes of southern France, Spain, Portugal, Italy, he warmer districts generally. The grapes of northern origin are ngly represented. Some Persian grapes, as elsewhere noted, are grown for the station; many grapes of Syria have been sent for e Agricultural Department.

TREES PLANTED AT POMONA.

APPLES.

nassia.
nite Astrachan.
oover.
enton Early.
dy.
rry Russet.
ealthy.
rslop Crab.
rly Ripe.
exander.
nathan.
enty Ounce.
wver.
waukee.
W. Pearmain.
ntreal Beauty.
avenstein.
abskoe.
inner's Pippin.
imes' Golden.
tley.
albridge.
rk Imperial.
Keswick Codlin.
Colvert.
Red Bietigheimer.
Duke of Devonshire.
Missouri Pippin.
Sonoma.
Yellow Bellflower.
Whitney.
Red Astrachan.
Fameuse.
R. I. Greening.
E. Spitzenberg.
Northern Spy.
Stump.
Yellow N. Pippin.
Yellow Siberian.
Sweet Bough.
Reinette de Caux.
Belle de Booskop.
McMahan's White.
Smith's Cider.
Wolf River.
Transcendent.

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Pears.

Beurré Giffard.
Beurré Clairgeau.
Beurré Hardy.
Beurré d'Anjou.
Clapp's Favorite.
B. S. Fox.
Frederick Clapp.
Laurence.
Easter Beurré.
Vicar of Winkfield.
Gray Doyenne.
Howell.
Court Queen d'Autumne.
Henry IV.
Iconneau Von Mons.
Jalousie Fontenay Vendée.
Maréchal Vailliant.
Napoleon III.
Eugene Appert.
Louis Vilmorin.
Epine Dumas.
St. Crispin.
Sarah.
Pitmaston's Duchesse d'Angoulême.
Souvenir d'Esperen.
Beurré Golden of Bilboa.
Madame Loisel de Barney.
Princess St. Germain.
Marie Louise d'Uccles.
Baronne de Trello.
Passe Colmar.
Duchesse de Mouchy.
Beurré de l'Assomption.
Duchesse de Bordeaux.
St. Michael Archangel.
Bonne du Puits Ansault.
Brockwell Park.
Duchesse d'Angoulême.
Le Conte.
Bartlett.
Madeleine.
Souvenir du Congrès.
Winter Nelis.
Seckel.
Glout Morçeau.
Beurré Gris d'Hiver.
Lawson.
Dr. Reeder.
Paradise d'Automne.
Doyenne Sieulle.
Augustus Dana.
Jones' Seedling.
Fondante de Noël.
Ott.
Star of Bethlehem.
St. André.
Williams' D'Hiver.
Levard.
Duhamel de Monceau.
Anne Ogereau.
Chaumontel.
Pater Noster.
Theresa.
Duchesse d'Orleans.
Smith's Hybrid.
P. Barry.
Figue d'Alençon.
Napoleon.
Maurice Desportes.
Belle Williams.

Cherries.

Belle Magnifique.
Guigne Tres Précoce.
Rockport Bigarreau.
Centennial.
Olivet.
Early Richmond.
Napoleon Bigarreau.
Black Tartarian.
Willamette.
Tradescant's Blackheart.

Plums.

Bavay's Green Gage.
Coe's Golden Drop.
Duane's Purple.
McLaughlin.
Prince of Wales.
Smith's Orleans.
Washington.
Bradshaw.
Blue Damson.
Ickworth's Imperatrice.
Pré. de Bergthold.
Royal Hâtive.
Yellow Egg.
Jefferson.
Drap d'Or d'Esperen.
Simoni.
Judson.
Satsuma.
Monroe Gage.
St. Lawrence.
Botankio.
Reine Claude Rouge.
Belgian Purple.
Goliath.
Denison's Superb.
General Hand.
Peter's Yellow Gage.
Joe's Autumn.
Long-fruited Japan.
Lucomb's Nonesuch.
Botan.
Czar.
Green Gage.
Perdrignon Blanc.
River's Early Prolific.
Yellow Gage.
Belle de Septembre.
Coe's Late Red.
Early Golden Drop.
Mariana.
Quackenbos.
Victoria.
Ontario.
Wine Sour.
Black Morocco.
Burbank Japan.
Copper.
Red Egg.
Kelsey Japan.
Shropshire Damson.
Lombard.
Bryanstine Gage.
Masu Japan.
Guthrie's Late Green.
Autumn Compote.
New Large Bullace.

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Prunes.

rignole.	German.
. Martin's.	French.
atte de Hongrie.	Silver.
Yangenheim.	Fellenberg.
. Catherine.	Tragedy.
laister.	Bulgarian.
obe de Sergent.	Grosse Prune d'Agen.
etite Prune d'Agen.	

Peaches.

lexander.	Chinese Cling.
oster.	Mountain Rose.
ichol's Orange.	Picquet's Late.
ller's Cling.	Henrietta Cling.
ate Crawford.	McDevitt's Cling.
ard's Late.	Wilkins' Cling.
msden.	Briggs' May.
oolidge's Favorite.	Gov. Garland.
orris' White.	Old Mixon Free.
unyon's Orange.	Susquehanna.
arge Early York.	Lemon Cling.
ump.	Waterloo.
ellow St. John.	Blood Cling.
alifornia Cling.	Early Crawford.
os Mignon.	Newhall.
d Mixon Cling.	Salway.
eath Cling.	Late Admirable.
ovell.	Smock's Late.
ord's Improved.	Comet.
aley (Cal.) Seedling.	Muir.
ineuse.	Haines' Early.
arly Alfred.	Tippecanoe Cling.
agmar.	Late Morris' White.
ucelle de Malines.	Tuscany Yellow Cling.
cKevitt's Cling.	

Apricots.

arly Moorpark.	Pringle.
. Ambroise.	Newcastle Early.
oorpark.	Early Rivers.
urkey.	Oullin's Early.
rdinian.	Viard.
uizet.	DeCoulorge.
riggs' White.	Hemskirke.

Nectarines.

ctoria.	Downton.
tmaston's Orange.	Red Roman.
arly Newington.	River's Orange.

Almonds.

ommercial.	Golden State.
anguedoc.	Nonpareil.
ver Shell.	Drake's Seedling.
K L.	Marie Dupuys.
per Shell.	Sultana.
at-fruited.	King's Soft Shell.
e Plus Ultra.	Pistache.

Figs.

gen.	Angelique.
l di Signor Bianca.	Du Roi.
izzly Bourjasotte.	Gros Grise Bifera.
irta du Japon.	Monace Bianca.
egro Larga.	Ronde Violet Hâtive.
ianzola.	Trojano.
ogiatto (black).	Smyrna (wild).
ubrado.	Dattato (white).
nvito.	San Piero.
myrna.	Brogiatto (white).
attato (black).	Giugliono.

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Olives.

Amellan.
Atro-violacea.
Lucques.
Manzanillo.
Nevadillo blanco.
Polymorpha.
Præcox.
Regalis.
Salonica.
Huff's Spanish.
Atro-rubens.
Columbella.
Macrocarpa.
Nigerrima.
Oblonga.
Polymorpha (of Sorry).
Pendulina.
Rubra.
Verdale.
Berkeley Seedlings.

Citrus Fruits.

Oranges.

Washington Navel.
Sanguinea.
Pineapple.
Tardiff.
Tangerine (Dancys).
Otaheite.
Konah.
Florida Sour.
Malta Blood.
Jaffa.
Mediterranean Sweet.
Parson Brown.
King.
St. Michaels.
Mandarin.
California Seedlings.

Lemons.

Villa Franca.
Genoa.
Sweet Rind.
California Seedlings.
Sicily.
Eureka.
Lisbon.

Other Citrus Fruits.

Mexican Lime.
"Grape Fruit," of Florida.
Calabria Citron.
Citrus Trifoliata, of Japan.
Shaddock.
Amalfi Citron.
Sorrento Citron.

Japanese Persimmons.

Hachiya.
Funo Kaki.
Yemon.
Memo-gaki.
Yane Nashi.
Lenji Maru.
Hiya Kume.
Giboshi.

Pomegranates.

Sweet-fruited.
Spanish Ruby.
Sub-acid.

Miscellaneous.

Loquat—large-fruited.
Psidium Cattleyanum.
Mulberries in var.
Carob.
Kai Apple.
Kunzea pomifera.

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III.

REPORTS

ON

ECONOMIC ENTOMOLOGY AND INSECTICIDES.

School Instruction in Entomology.

Spray and Band Treatment for the Codlin Moth.

Variation in Hessian Fly Injury.

The Use of Gases Against Scale Insects.

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PORTS ON ECONOMIC ENTOMOLOGY AND INSECTICIDES.

SCHOOL INSTRUCTION IN ENTOMOLOGY.

By Edward J. Wickson.

an Act of the California Legislature, approved March 15, 1887, on 1665 of the Political Code was amended so as to include "Prac- Entomology" among the branches in which instruction must be in the public schools. This requirement was made by the Legis- e at the earnest solicitation of the fruit growers, who claimed that ing the children to recognize injurious insects, and to understand thing of their life-history, would be the most direct and expeditious to popularize this information, and to overcome the ignorance and essness which have always been the best friends of injurious insects he greatest opponents of progressive horticulture. The idea of the growers in securing this legislation was not alone that the rising ation might yield an increased crop of economic entomologists, would be a remote benefit; rather was it expected to reap imme- results, because interesting the children in the rudiments of the ce would soon spread a knowledge of them abroad throughout the nunity.

far as known to the writer, California is the first State of the n to provide specifically for entomological instruction in the public l. Other States have provision for zoölogy, which might include nology if the teacher so desired; but in most cases the requirement öology was reduced to something like "stories about animals." California requirement cannot thus be parried, because, though the oes not define "Practical Entomology," there is in most rural dis- a public sentiment which admits of no misconstruction. This al awakening of the California public on the subject of economic nology is, at the same time, a warning to the teacher that the law be complied with, and is a great help to all teachers who make a ientious effort to do their duty in this respect.

the subject is so new to our public school teachers, and is by its nature difficult, there has been a constant appeal to the University dvice and suggestion as to instructional methods and material. fact that there has been for some time no elementary text-book able made the subject the more appalling to the teacher. The work by the late Matthew Cooke speedily went out of print, and gh the State bought the copyright and plates, no provision was for the reissue of the work. The possibility of the reappearance s book as one of the State series of school text-books has probably nted effort in the same line by private publishers.

view of the evident need of aid and encouragement to teachers in new requirement made upon them, I have given considerable time g the last year to such service as I could render in this direction. has consisted, in part, of attendance at teachers' institutes in a er of counties, and in consultation and correspondence with indi- al teachers. The grounds taken may be briefly outlined as follows:

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1. No satisfactory work can be expected unless the teacher wi
the time and application necessary to secure an elementary kno
of the science and the ability to recognize the chief injurious and
ficial species of the region in which he is teaching.

2. To enable the teacher to do this the school library should c
several elementary and popular treatises on entomology, togethe
the publications of the University Experiment Stations, the Cali
State Board of Horticulture, and of the Division of Entomology
United States Department of Agriculture, so far as it is possible to
them. The school should also be provided with a number of
magnifiers, and, wherever possible, with a compound microscope.

3. Much assistance is usually to be obtained by appeal to the C
Horticultural Commissioners in counties having such officers.
fruit-growing neighborhoods there are also well-informed orch
and vineyardists who have, by necessity, become possessed of con
able knowledge of injurious insects and the methods of repressing
If the teacher shows willingness and interest, such men and wome
assist them greatly in the effort to present the subject to the pupi

4. It is useless to attempt instruction in entomology by any
than the object lesson. *Instruction should be given with the
specimens in the hands of the pupil at the time.* This is not
necessary for the correct apprehension of the elements of the sc
but it awakens and holds the pupil's interest; it trains his pow
observation and discrimination, and it secures directly the pra
results contemplated by those who urged the adoption of the law r
ing the instruction, in that the pupil learns to determine the eco
character of the insects which come before him.

5. It is not advisable to attempt too much in the way of clas
tion. Entomological classification is exceedingly difficult, beca
the vastness and diversity of the insect fauna. If the teacher
nately has some little knowledge of the subject by previous traini
can readily interest the children in classification up to a certain
If not, he can, by a little study of books and insects, acquire the a
to classify into orders, and in some cases into families; and h
determine genera and species of the most prominent injurious an
eficial insects by the aid of the State and United States reports.
if he should shrink from this, but should take pains to know
species at sight, and should learn by book and specimen the transf
tions, the injury or benefit they work, and the means of destroyin
injurious and protecting the beneficial species, he would still be a
deeply interest his pupils and comply with the law.

6. The teacher will find his effort easier and more effective if he
his pupils to the fullest coöperation; encouraging them to make
tions, and to bring their "finds" to the school-room. The teacher s
not be afraid to tell the pupils frankly if the specimen is beyo
knowledge. It may even deepen their interest to know that the
men must be sent to the State University, or elsewhere, to ha
standing determined. Let the teacher give a half day on a Saturd
an excursion after insects. Let him take the class to orchards
spraying or other insecticidal warfare is in progress, and as
orchardist to explain his operation, and the reason for it.

7. In the absence of books suitable for use in grammar grades as
books, instruction must needs be oral, and in view, also, of the cr

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tion of the grammar school curriculum, it is just as well that such is
ase. Oral instruction with specimens is the most direct method of
aching the pupil and of imparting lasting impressions. But oral
ction does not signify that the teacher must prepare a lecture for
esson, though in presenting some insects it may be desirable to
The pupil can recite as well from a specimen before him as from
ur's study of a text-book. More than that, as will be shown in
ase of a teacher whose experience will be introduced later, the
nen may be used as a language lesson, as an exercise in free-hand
ng, and otherwise, thus making the most direct compliance with
w, and serve several other useful purposes.
The desirability of permanent collections by pupils should not be
oked. Such collections have in many cases proved the most
sting features of the "last days" of school, and have won free
ation from parents. During the making of such collections, not
he pupils but their parents learn much about insects; and this,
eady intimated, is one of the ends aimed at by those who urged
quirement of this study in the schools. Permanent collections of
s, mounted dry, are, however, very perishable under such care as
ually be given them in the school house. A more durable method
preserve all insects, except butterflies and moths, in small vials
with three fourths alcohol to one fourth water. Homeopathic
will contain all save the largest species. If in each tiny vial are
l the forms of the same insect which can be found, and notes made
plant on or in which each is found, the vial will continually pre-
condensed life-history of the species, that is, perhaps, inferior to
ved museum methods, but has the merit of durability under hard
or neglect, which museum specimens do not have.

WHAT THE SCHOOLS ARE DOING IN ENTOMOLOGY.

en it appeared that much of my time must be given to the subject
consideration, an effort was made to ascertain how widespread
ne effort to comply with the law, and what success was being
ed in introducing the subject into the schools. With this in view,
of inquiry were addressed, in October, 1890, to each County
ntendent of Schools, and to City Superintendents as well. Not
rsons addressed replied, but enough responses were received to
assurance that many are making an honest effort, and that in
cases most gratifying results are being reached. An outline of
rrespondence is presented herewith:

Welsh, County Superintendent, Redding, Shasta County.—Our teachers make but
ogress teaching entomology. I think the principal reason for this is that the text-
use (Cooke's) is not fit for the average country school.
t A. Grover, County Superintendent, Markleeville, Alpine County.—I am very sorry to
most of our teachers take but little interest in teaching practical entomology.
Braddock, County Superintendent, Oroville, Butte County.—There is a growing inter-
n by the teachers of this county in the subject of practical entomology. For the
years the subject has been brought before the Teachers' Institute, and there
d with considerable earnestness, showing that the teachers fully appreciate its im-
. A small manual, to be used in conjunction with Cooke's School Entomology,
e a valuable aid to the teacher.
Lyman, County Superintendent, Yuba City, Sutter County.—Much good work has
ne in the line of practical entomology in the public schools of this county, and I
th the present outlook, that we will greatly improve the work in a year or two.
ctions to its introduction are seldom hea d now.
Furlong, County Superintendent, San Rafael, Marin County.—The progress made

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since the introduction of practical entomology into the schools of Marin County been satisfactory. Encouraging results have been attained in a few schools whe ers, fond of natural history, are at work; but in the greater number of our sc requirement of the statutes is barely complied with. Marin, as a whole, is no county, and school patrons object to their children "wasting time studying abou The average school patron looks upon the education of his child from the pract only. It requires argument to convince him that the child is being educated for t instead of a single district or county in which he lives. One enthusiastic teache position because, as was alleged, "he spent too much time teaching about bugs." ever, in some sections of this county, the fruit interests are considerable, and not schools but the patrons also are much interested in entomology. Our teachers are ing themselves in this branch. The want of a manual or guide in teaching thi has been a drawback. Few teachers are sufficiently familiar with the subject to well without a text-book to guide them.

Mrs. F. McG. Martin, County Superintendent, Santa Rosa, Sonoma County.—Our and schools have done most creditable work in practical entomology; many have formed valuable collections of insects, and all seem to take special intere subject.

L. J. Chipman, County Superintendent, San José, Santa Clara County.—Our teac doing very well indeed with entomology, when we take into consideration its d and the want of a first class text-book on the subject.

J. N. Thompson, County Superintendent, Hollister, San Benito County.—The su practical entomology being new to many teachers, it has not been as successfull in the past as I hope it will be in the future. Some of our teachers are doing e work. I find that pupils soon become interested, and take great delight in c specimens, in distinguishing the beneficial, and in learning remedies for the inj

Job Wood, Jr., County Superintendent, Salinas City, Monterey County.—Our teac trying to make the teaching in entomology beneficial. Books are poor, but th themselves are furnishing lessons. The powers of observation are being develo we hope to see good results.

A. D. Tenny, City Superintendent, Salinas City, Monterey County.—Your commu was handed to the teacher who has charge of the subject of entomology in the g grades of our schools, and the inclosed is the statement she has kindly made. add that in my own experience I have suffered from lack of books as guides for the subject. I think, too, that there are too many studies required in our public and it would be well to make some provision for omitting, or greatly abridging, them, that more time may be given to others.

Belle Duncan, Teacher of Entomology, City Schools, Salinas City, Monterey Coun classes in entomology use no text-books, but take notes in blank-books. We ha library a number of the latest works on insects injurious and beneficial to orch gardens. We have brought into class infested leaves, branches, and bark, and wi glasses and specimens in the hands of pupils, read from all authors accessible. making a solar microscope and heliostat, with which to enlarge upon canvas s we have already mounted.

B. F. Howard, County Superintendent, Sacramento.—The study of entomology been very vigorously prosecuted in this county. Our course of study requires advanced grade. We have also supplemented that requirement with the fo "Practical instruction should be given in all the grades; special attention sh given to the insects injurious to fruit; bring in specimens of the most comm and encourage the children to do the same." It is safe to say that many of th of the county do not study the subject to any great extent.

W. M. Nuner, County Superintendent, San Andreas, Calaveras County.—I find in m ence that the teachers of this county are very much displeased with entomol cannot give you a favorable letter on the subject.

George F. Mack, County Superintendent, Ione, Amador County.—Our teachers are entomology only in a general manner. It is really a difficult matter to get te take hold of the subject in an earnest way.

A. J. Tiffany, County Superintendent, Nevada City, Nevada County.—Most of the of this county are doing fairly well with the subject of entomology. The text- poor one for practical use, and should be revised; the subject is a new one, and book should be the very best. I am glad to say that all the schools are receiving ins and are doing as well as could be expected.

Mrs. W. D. Egenhoff, County Superintendent, Mariposa, Mariposa County.—So littl done with entomology in the schools of this county that I have nothing of importance to communicate to warrant entering into details.

Alfred Harrell, County Superintendent, Bakersfield, Kern County.—In my opinion, duction of practical entomology into the schools of this county has proved a fail term "practical entomology" is a misnomer. The subject receives scant atten the work is confined chiefly to the text-book.

J. S. Shannon, County Superintendent, Bishop, Inyo County.—Entomology has be with success in some of our schools, yet not as generally as we wish. Many teac not taken instruction in that branch, as it is a new requirement, and are not pared to do justice to it. It will grow as a study as our new country grows ol are not troubled with insect pests as in many other places, hence our pupils do n the interest they should take in the matter.

Will S. Monroe, City Superintendent, Pasadena, Los Angeles County.—The subjec

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has received considerable attention in the schools of our city. During the past
ects were studied for several months in the fifth, sixth, and seventh years. Our
s *a study of typical insects*, and we usually took a week for each subject. We
only such insects as the pupils themselves could procure. Each pupil was
to have at least one insect. We developed the subject as follows:
Lesson: Oral language; the pupils examine their insects and make statements of
ervations.
l Lesson: Drawing; insect drawn from the insect.
Lesson: Written language; pupils reproduce, in their own language, all they
rned about the insect.
n Lesson: Correction and copying; pupils correct and copy the written lessons.
Lesson: Dissecting and mounting; pupils dissect the insect studied, and mount
stol board.
way we studied beetles, crickets, bees, butterflies, and other insects. Our object
ork was: (1) To train in habits of observation; and (2) to furnish materials for
expression in the language and drawing. The interest taken in the work, by
ils and teachers, was marvelous.
reliminary training paved the way for the more formal study of entomology in
th year. Here Cooke's Entomology was introduced. The use of this book has
satisfactory, and this year we provided for three months' supplementary reading
nology in the eighth year, using Mrs. Tenny's "Bees, Butterflies, and Other
" with admirable results.
subject of entomology is to be taught practically, it must be from insects rather
m books. The pupil should be required to study only a *few* insects in *each* of the
orders, and study these few so thoroughly that he may make for himself a com-
study of insects belonging to the same order.

he number of City and County Superintendents addressed in the
of this inquiry only about one third replied. The writer is
from observation and otherwise, that entomological instruction
g given with satisfactory results in other counties than those
above, and in others, in all probability, it is shunned or neg-
Probably the above showing from one third of those in the
t is a fair representation of the whole. As such, it must be
ed as quite favorable, considering the difficulties which are freely
y the correspondents, and others which are obvious. It is also
hat the subject is making quite as satisfactory progress as could
ected. The general sentiment of the leading educators of the
oward entomology as a public school study was sharply defined
eneral meeting of County Superintendents in Sacramento last
when a resolution protesting against the requirement was
voted down; and intimation was given in the discussion that
who were disposed to oppose the subject had not made fair trial
nd consequently did not know to what advantage it could be
It is fair to expect that this opinion of the majority of those
made fair trial of the subject will prevail even more widely in
ure, and that school work in economic entomology will go for-

ASSISTANT IN ENTOMOLOGY.

station has been fortunate in securing the services of C. W.
orth, M.S., as assistant in entomology. Mr. Woodworth's train-
an entomologist, and his work in both the scientific and economic
es of his profession, attest his fitness to extend the efficiency of
tion in directions of the greatest importance to California agri-
sts.

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SPRAY AND BAND TREATMENT FOR THE CODLIN MOTH

By C. W. Woodworth.

In Bulletin No. 75 of this station Professor Wickson gave, unde
above caption, a preliminary account of some experiments condu
under his direction at the University. The following article will
sent all the results reached by the experiments, and a more exhau
discussion of the subject:

THE USE OF ARSENITES.

The success reported by Prof. S. A. Forbes, State Entomologi
Illinois, in spraying with Paris green for the destruction of the l
as soon as it begins to feed in the calyx of the apple, and similarly
results reported by several California apple growers, suggested th
set of experiments with arsenic and its compounds should be mad
the University orchard, where more time could be given to an accu
account of results than a busy fruit grower could devote to such w
As it was known that the late W. G. Klee, then State Inspector of
Pests, was conducting similar experiments on his own farm, and
keeping accounts of experiments by others, it was thought best tha
University experiment should be given a direction similar to his,
the results of all experiments could finally be brought together
serve for purposes of a wide generalization. For this purpose Mr.
was invited to prescribe the applications to be made. He did so,
assisted personally in the preparation and application of the poiso
a service for which we make due acknowledgment.

Application was made of three substances—white arsenic, Paris g
and London purple—and each in different strengths, as will be spec
in the tables which will be given below. The white arsenic was
solved in hot water; the Paris green and London purple were kep
thoroughly stirred as possible while being drawn up by the pump.
drenching of the trees was quite complete, the spray being especi
directed upon the clusters of fruit, which, in most cases, were
upright, so that the drops of the liquid were caught and held in
calyx end. There was, of course, much difference in the size of
fruit, as the orchard comprises a large collection of summer, fall,
winter fruit. Trees were selected, however, as carefully as poss
which had the fruit of the best stage of growth, say from the size
pea to that of a small marble, at the time of the first spraying.

The tables will show that in most cases three applications were gi
all within thirty days from May third. During that period the rec
of the University Meteorological Observatory show that rain was n
ured but once, and then but one twentieth of an inch, and in the m
of June there was but a sprinkle, even less in amount, so that
weather was perfect for the retention of the poison on the fruit.

The University orchard is planted with two trees of each var
and in these experiments one was sprayed and the other rese
without treatment, so that a comparison, each tree with one of its
variety and age, could be made. The orchard was guarded in su
way that no outside interference could be had with the fruit. Tw
week all the fruit which fell from the sprayed trees and from the c

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H.

	ted Trees.		Untreated Trees.		Decrease.	
	Fruit Injured.	Larvæ Found.	Fruit Injured.	Of Larvæ.	Fruit Injured.
One F						
Nouveau Poite	7	8	12	18	5	10
Nantais	2	2	0	4	—2	2
Red Canada	3	3	11	27	8	24
Totals	12	13	23	49	11	36
One F						
Duchesse Précd	1	3	4	6	3	3
Dr. Reeder	1	0	18	10	17	10
Chaptel	1	5	1	0	0	—5
Duchess of Old	0	0	0	0	0	0
Fameuse	0	9	1	4	1	—5
Totals	3	17	24	20	21	3
One Pound to 160						
Buerre Gris d'I	2	3	2	1	0	—2
Wells' Sweet	1	3	1	1	0	—2
Duchesse Mign	1	1	4	9	3	8
Totals	4	7	7	11	3	4
Totals for Pa	9	37	54	80	35	43
One F						
De Tongrest	4	9	8	14	4	5
St. Michael Ar	1	3	0	0	—1	—3
Disharoon	4	7	7	2	3	—5
Yopps' Favori	3	3	3	6	0	3
Totals	12	22	18	22	6	0
One						
Emile de Heys	4	15	5	4	1	—11
Madame Treyv	0	0	11	18	11	18
Augustus Dan	0	0	2	2	2	2
Seek No Furth	2	16	25	36	23	20
Totals	6	31	43	60	37	29
Totals for Lon	8	53	61	82	43	29
One Po						
Callebasse Mo	2	2	3	0	1	—2
Grimes' Golden	1	1	0	0	—1	—1
Totals	3	3	3	0	0	—3
One F						
Ott	0	0	1	0	1	0
Early Joe	0	0	7	15	7	15
Totals	0	0	8	15	8	15
One Pound						
Napoleon	0	1	0	3	0	2
Hall	7	23	No	check.		
Totals	7	24	0	3	0	2
Totals for Wh	0	27	11	18	8	14
Grand totals	4	117	126	180	86	86

Considerable settling

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unsprayed, was examined and careful entry made, in a book pre-
for the purpose, of all worms found in the fruit, of all fruit from
the worms had escaped, and of the number of worms found under
nds of sackcloth which were placed upon all the trees. This
f procedure was faithfully carried out until November first, when
fruit remaining at that time was removed from the trees, exam-
or worms, and the experiment closed.

large table herewith shows a summary of the results.

column headed "Yield" gives the marketable fruit picked from
ees; when the amount was less than a half box per tree it is
d zero. No record was kept of the fallen fruit not affected by the
moth.

se applications were all made to affect the first brood of the moth.
gures of infested fruit are all small, for, in Berkeley, as in most
along the coast, at least, the first brood of the moth was unusu-
nall this year. This fact would not necessarily interfere with the
tage of gain by the treatment. In the case of the white arsenic
mber of the trees and of worms is too small to give valuable
.

codlin moth is said to deposit anywhere from fifty to two hundred
nd so a single moth, by presence or absence, might produce a great
nce in an experiment. When the pest is abundant there is, of
less danger of such results.

experiments with Paris green are more satisfactory, as more trees
cluded, and worms are found on nearly all, which shows that the
visited the trees more freely. The percentages of gain must be
ered very satisfactory, and the stronger applications produce the
sults. The application of a wash with one pound of Paris green
hundred and sixty gallons of water is very satisfactory, giving a
se of about one half in the number of worms observable, or a
of two thirds of the fruit which would otherwise have been
d.

London purple was used too strong, and shows, when estimated
number of worms actually seen, a decrease much larger than in
ris green experiments, but only a comparatively small gain when
ted on the basis of the relative amount of injured fruit.

ng the experiments as a whole, we find, estimating on the basis
number of worms actually seen, a saving of two thirds, or, accord-
the amount of injured fruit, a saving of one half. The latter
is probably nearer correct, and accords well with Eastern experi-
It may be put down as established that fully one half of the fruit
rily eaten by the codlin moth can be saved by spraying.

EXAMINATION OF THE BAND TREATMENT.

rder to determine some points about the efficacy of banding apple
ear trees for the destruction of the larvæ of the codlin moth, an
te record has been kept in the University orchard during the past
. The bands were put on early, and consisted of strips of old
The strips were five or six inches wide; the ends were allowed
well, and the band was secured by a string tied around near the
so as to furnish crevices at both the upper and lower edges, to
modate worms coming from either direction. All these bands were

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removed on a certain day each week, the larvæ counted and killed, and the bands replaced. At the same time all the fallen fruit was gathered, examined for worms, or to see if worms had escaped, and records of these facts kept separately. The following table gives a summary of the results:

Results of Band Treatment on Larvæ of Codlin Moth.

	Larvæ Under Bands.	Larvæ in Fruit.	Other Damaged Fruit.	Number Trees in Row.
Pears—Row No. 9	32	27	76	22
Row No. 10	43	58	141	35
Row No. 11	73	43	130	37
Row No. 12	131	37	178	38
Row No. 13	59	36	117	38
Row No. 14	138	37	235	39
Row No. 15	86	55	237	38
Row No. 16	48	19	100	16
Apples—Row No. 16	4	1	19	17
Row No. 17	94	50	201	32
Row No. 18	65	19	113	25
Row No. 19	94	89	449	24
Row No. 20	170	70	350	26
Row No. 21	88	45	154	25
Row No. 22	33	23	84	21
Row No. 23	82	32	201	16
Row No. 24	5		8	9
Totals	1,245	641	2,793	457

This summary shows that while two thousand seven hundred and ninety-three apples and pears were found from which worms had escaped, there were found under the bands but one thousand two hundred and forty-five, or 44 per cent; the remaining 56 per cent includes worms which found nesting places elsewhere or perished. The assistant who kept the record of this experiment, assures me that he believes many of these were eaten by birds which were always working over the ground while he was in the orchard. The others must have concealed themselves under clods to spin their cocoons, for there is no loose bark on the trees, and no rubbish or fences in which they could hide.

It is thus seen that less than half the worms are destroyed in this way, and that they are not killed till they have completed their injury to the fruit; still it is not wholly unsatisfactory. Could it be shown that this ratio of destruction was maintained against the first brood, it would probably indicate a large percentage of saving of fruit.

From the nature of the case no definite results as to the saving of fruit through the band treatment can be demonstrated by experiment, and it is generally concluded that except in isolated orchards but little is accomplished except by concerted action of all orchardists in the neighborhood.

OTHER RESULTS FROM THE EXPERIMENTS.

With many insects the use of resistant varieties has proved the most satisfactory, if not the only practical remedy. Wherever there is observable a decided preference, even for one variety of plant over another, good results may be expected. When it is simply a preference, the planting of only the varieties that are least preferred will not suffice, but

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use of a few trees of a preferred variety in an orchard of unpreferred t will reduce the fight to those few trees. If these are thoroughly soned good results should be expected without treating the other trees. The following lists will show the varieties decidedly below or above average of injury by the codlin moth, and does not include those ose small yield would make the results especially doubtful.

Of *pears* the following were but little injured:

America.
Ananas d'Eté.
Andrews.
Augustus Dana.
Baronne de Mello.
Belle Lucrative.
Belle Williams.
Beauprésent d'Artois.
Beurré de l'Assomption.
Beurré Golden of Bilboa.
Beurré Précoce.
Beurré Sterkmans.
Bloodgood.
Bonne d'Ezée.
Bonne du Puits Ansault.
Brandywine.
Brockworth Park.
Clapp's Favorite.
Conseiller de la Cour.
Court Queen d'Autumne.
Dana's Hovey.
Dearborn's Seedling.
Doyenne d'Eté.
Doyenne du Comice.
Doyenne Robin.
Doyenne White.
Duchesse d'Angoulême.
Eugène Appert.
Flemish Beauty.
Inconnue Von Mons.
Josephine de Malines.
Louise Bonne de Jersey.
Madame Cuissard.
Madeline.
Manning's Elizabeth.
Marie Louise d'Uccles.
Osband's Summer.
Pater Noster.
Rostiezer.
Rousselet Stuttgart.
Rutter.
Seckel.
St. André.
Star of Bethlehem.
St. Crispin.
St. Michael Archangel.
Tyson.
Urbaniste.
Washington.

The following showed more than the average injury:

Bartlett.
Bergamotte Cadet.
Bergamotte d'Esperen.
Beurré d'Aremberg.
Beurré Diel.
Beurré Goubalt.
Beurré Langeier.
Bezi Sanspareil.
De Tongress.
Doyenne Boussock.
Doyenne Sieulle.
Duchesse de Mouchy.
Duchesse d'Orleans.
Edmonds.
Epine Dumas.
Jaminette.
Lawrence.
Maurice Desportes.
Napoleon the Third.
Nantais.
Oswego Beurré.
Stevens' Genesee.
St. Germain.
Swan's Orange.
Williams' D'Hiver.

Of *apples* the following were not much injured:

Count Orloff.
Garretson's Early.
Gravenstein.
Hall.
Pomme Royale.
Primate.
Summer Queen.
Sweet June.

Those that were much injured are:

Berry.
Golden Sweet.
Maverick Sweet.
Ortley.
Roxbury.
Russet.

No attempt has been made to follow out the life-history of the codlin th in this particular region. It is a well known fact that the number broods vary in different regions. It is probable that in a climate as rm as this there is hardly any such thing as broods in the ordinary of the term. All sizes may be seen at any time in the fall, and for ay treatment application must be made later on the winter fruit than the summer or fall varieties to destroy the later worms. The follow- table will show the varying amount of injury:

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Season Result of the Spray Treatment.

Season.	Number of Trees.	Larvæ per Tree.	Injured Fruit per Tree.
Pears—Summer	18	7.61	8.76
Fall	37	6.62	10.46
Winter	38	11.10	18.91
With small yield	47	1.97	3.18
Apples—Fall	8	1.12	1.78
Winter	21	16.42	38.41
With small yield	92	6.42	10.85

The varieties which gave too small a yield to give reliable results were all put together, instead of in their proper classes. It will be seen that the injury to winter fruit greatly exceeded that to summer and fall fruit.

VARIATION IN HESSIAN FLY INJURY.

By C. W. Woodworth.

The appearance of the Hessian fly in the experimental plots in 1885, in such numbers as to vitiate the culture and fertilizer experiments then under way, gave opportunity the following year of making a test of the relation between the variety of the grain and the injury by Hessian fly under conditions very favorable to such experimentation. The results obtained in 1886 were published in Bulletin 58 of the Experiment Station, and more fully in the report for 1887. These observations were repeated in 1887, 1889, and in 1891, and it is thought that the confirmatory evidence thus obtained make the results of considerable value.

The University grounds are quite isolated from other fields in which grain is grown, and but for that sown for hay, there would be hardly a possible chance of infection from without. Wheat had been grown on the grounds for several years, but the fly had only appeared in such destructive numbers the year before these experiments began. The same field was used in 1886, 1887, and 1889, the dates of sowing being February 24 and 25, 1886; a few were sown January 18, 1887, but most of them on the twenty-fourth; and in 1889 they were all sown the second of February. Not planting in 1888 did not seem to have any effect on the flies; but from this cause or some other, they were almost completely exterminated this year, for careful search, even in the most susceptible varieties, showed but very few "flax seeds."

The following table will show the observations on wheat, made during the three years that the fly was abundant:

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Variety.	1886.			1887.			1889.		
	Crop.	Harvest.	Flies.	Crop.	Harvest.	Flies.	Crop.	Harvest.	Flies.
Archer's Prolific	Poor		Few	Fair	July 15	Abundant.	Very poor.	July 15	Abundant.
Arizona Indian seed	Failure	July 28		Poor	July 8	Abundant.	Poor	July 15	Abundant.
Arnold's Gold Medal	Failure		Abundant.	Poor	July 8	Abundant.	Failure		
Austrian	Poor	July 28	Abundant.	Fair	July 28	Abundant.	Very poor.	Aug. 7	Abundant.
Bearded Macaroni	Fair	July 19	Few	Poor	July 11	None			
Bearded wheat from Missoyen	Poor	July 19	None	Good	July 16	None	Fair	July 25	Very few.
Beardless Velvet	Failure		Abundant.						
Big Long-bearded Club	Fair	July 19	Few	Failure			Fair	July 25	Very few.
Big White Club	Very poor.	July 28	Abundant.				Poor	July 25	Abundant.
Big White Club (Oregon)	Poor	July 28	Abundant.	Good	July 15	Few	Fair	July 15	Few.
Black Bearded Centennial	Failure			Good	July 28	Abundant.	Very poor.	Aug. 17	Abundant.
Black Bearded Spelt				Fair	July 28				
Black Emmer Spelt	Failure								
Blood Red	Failure			Poor	Aug. 8	Abundant.	Failure		
Blue Bearded (Brenner)				Failure			Failure		
Blue Bearded Spelt	Fair	July 28	Abundant.	Fair	July 28				
Blue Glass	Fair	July 19	Very few.	Very poor.	July 21	None	Fair	July 2	Very few.
Bohemian	Failure			Poor	Aug.	Abundant.	Failure		
Brown Bearded	Failure			Failure			Failure		
Brown Spelt	Failure		Abundant.						
California Spring	Poor	July 19	Abundant.	Poor	July 21	Abundant.	Poor	July 25	Abundant.
Champlain	Poor	July 19	Abundant.	Poor	July 25	Abundant.	Poor	July 31	Abundant.
Chiddam	Failure			Poor		Abundant.	Very poor.		Abundant.
Chile	Very poor.	July 28	Abundant.	Failure			Failure		
Clawson	Very poor.	July 28	Abundant.	Failure			Poor	July 29	Abundant.
Common March	Fair	July 19	Very few.	Good	July 15	None	Fair	July 16	Very few.
Common White Bearded Spelt	Fair	July 19	Abundant.						
Cujavian	Failure			Failure			Poor	July 29	Abundant.
Defiance				Fair	July 21	Abundant.	Poor	Aug. 1	Abundant.
Diamond				Good	July 15	None	Fair	July 17	Very few.
Diehl's Mediterranean	Failure			Fair	Aug. 3	Few			
Dinkel Spelt	Poor	July 28	Abundant.						
Egyptian	Failure	July 28	Few	Good	July 15	Few			Very few.
Egyptian Imported		July 19		Poor	July 11	None	Fair	July 20	Very few.
Emmer		July 28	Few	Good	July 15	Very few.	Poor	July 29	Few.
Extra Early Oakley				Good	July 15	None	Poor	July 29	Abundant.
Fern, or April	Fair	July 28	Few	Poor	July 21	Abundant.	Poor	July 29	Abundant.

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OBSERVATIONS ON INJURY TO WHEAT BY THE HESSIAN FLY—Continued.

VARIETY.	1886.			1887.			1889.		
	Crop.	Harvest.	Flies.	Crop.	Harvest.	Flies.	Crop.	Harvest.	Flies.
F. Gates				Poor	July 8	Abundant.	Poor	July 15	Few.
Forell	Fair	July 28	None	Fair	July 21	None	Fair	July 15	Very few.
Four-rowed Sheriff				Poor	Aug.	Abundant.	Failure		
Frankenstein	Poor	July 28	Few	Fair	July 21	Abundant.	Fair	July 25	Few.
Fultz	Failure	July 28	Few	Good	July 15	Abundant.	Poor	July 14	Abundant.
Genoese Winter	Fair	July 28	Few	Good	July 11	Very few	Fair	July 29	Few.
Ghurka, or Odessa	Very poor.	July 28	Abundant.	Good	July 16	Very few	Fair	July 29	Few.
Golden Drop	Failure			Poor	Aug. 3	Abundant.	Failure		
Greek Atlanti				Good	July 18	Very few	Fair	July 24	Few.
Hallet's Genealogical	Failure			Poor	Aug. 3	Abundant.	Failure		Abundant.
Hallet's Original Red	Failure			Poor	Aug. 3	Abundant.			Abundant.
Hallet's Pedigree of White Victoria				Poor	Aug. 3	Abundant.	Very poor.	Aug. 17	Abundant.
Hungarian (Brenner)	Poor	July 28	Few	Fair	July 28	Abundant.	Very poor.	Aug. 7	Abundant.
Hungarian (Burke)	Poor	July 28	Few	Failure					
Hungarian (Mountain)	Fair	July 19	Few	Fair	July 18	Abundant.	Poor	July 31	Abundant.
Hunter's White				Good	July 18	Few	Fair	July 31	Very few.
Improved Circassian	Fair	July 19	Few	Good	July 21	Few	Fair	July 29	Very few.
Indian White Winter	Very poor.	July 28	Abundant.	Poor	July 3	Abundant.	Fair	July 25	Few.
Jonquil	Poor	July 28	Abundant.	Poor	July 18	Abundant.	Failure		
Little Club	Poor	July 19	Abundant.	Good	July 11	Few	Failure		
McGehee's White	Failure		Abundant.	Good	July 21	None	Very poor.	Aug. 17	Abundant.
Mammoth	Very poor.	July 28	Abundant.	Good	July 21	Few	Poor	July 25	Few.
Manchester				Failure			Very poor.	July 31	Abundant.
Martin's Amber	Failure				Aug. 15	Abundant.	Failure		Abundant.
Michigan Mixed	Poor	July 28	Abundant.	Good	July 21	Few	Poor	Aug. 7	Abundant.
Mold's Red Winter	Failure			Poor	July 3	Abundant.	Failure		Abundant.
Mold's White	Failure			Poor	July 15	Abundant.	Failure		Abundant.
Nicaragua				Good	July 11	Few	Good	July 15	Very few.
Nonette Lausanne	Fair	July 19	Very few	Good	July 8	Few	Good	July 20	Very few.
Nonpareil	Poor	July 22	Few	Fair	July 18	Abundant.	Fair	July 25	Few.
North Allerton	Failure			Poor	July 3	Abundant.	Failure		Abundant.
Paine's Defiance	Failure			Poor	July 3	Abundant.	Failure		
Palestine	Fair	July 13	None	Good	July 6	None	Fair	July 16	Very few.
Patent Office				Failure			Very poor.	July 29	Abundant.
Petali	Fair	July 13	None	Good	July 6	None	Fair	July 16	Very few.
Polish	Fair	July 19	Few	Good	July 16	None		July 20	Very few.
Prince Albert	Failure			Poor	July 8	Abundant.			

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Probsteier	Failure			Failure			Failure		
Proper				Poor	July 16	Abundant	Very poor	July 29	Abundant.
Propo				Fair	July 11	Abundant	Poor	July 16	Few.
Raub's Black Prolific				Good	July 15	None	Failure		
Red Bearded	Fair	July 12	Few	Poor	July 11	Abundant	Poor	July 17	Abundant.
Red Chaff	Poor	July 28	Abundant	Fair	July 18	Abundant	Poor	July 31	Abundant.
Red Club, or Hedgehog	Fair	July 19	Few	Good	July 16	Few	Poor	July 25	Few.
Red Emmer Spelt	Poor	July 19	Few	Fair	July 25				
Red Llama				Failure			Failure		
Red Sea	Poor		Abundant	Good	July 11	Abundant	Failure		
Red Sonora	Fair	July 13	Few	Poor	July 11	Abundant	Poor	July 17	Abundant.
Royal Australian	Poor	July 28	Abundant	Fair	July 11	Abundant	Poor	July 17	Abundant.
Russian Red Bearded				Good	July 18	Few		July 20	Few.
Rust Proof Indian				Fair	July 8	Abundant	Fair	July 15	Few.
Rye Wheat	Fair	July 28	Few	Fair	July 21	Abundant	Failure		
Short-bearded Club	Failure			Failure			Failure		
Siberian				Poor	July 28	Abundant	Failure		
Sicilian	Failure		Abundant	Poor	July 28	Abundant	Poor	July 20	Abundant.
Sicila (Brenner)				Failure			Failure		
Smoggi	Failure			Poor	July 15	Abundant	Failure		
Snowflake				Fair	July 21	Abundant	Poor	July 29	Few.
Square Sicilian	Very poor	July 13	Abundant	Fair	July 15	Abundant	Failure		
Taganrog		July 14	None	Good	July 11	Abundant	Fair	July 15	Few.
Thuringian	Poor	July 28	Abundant	Fair	July 28	Abundant	Poor	Aug. 7	Few.
Touzelle	Very poor	July 28	Abundant	Poor	July 28	Abundant	Poor	July 25	Abundant.
Tunisian	Failure	July 28	Abundant	Good	July 18	Few	Poor	July 7	Few.
Velvet Bearded	Failure			Failure					
Velvet Club				Failure			Failure		
Victor	Poor	July 19	Few	Fair	July 3	Abundant	Poor	July 25	Abundant.
Victoria	Poor	July 19	None	Good	July 21	None	Fair	Aug. 7	Few.
Volo	Good	July 12	None	Good	July 15	None	Fair	July 15	None.
Washington Glass	Very poor		None	Poor	Aug. 15	None	Failure		
White Banater	Very poor	July 19	Abundant	Good	July 25	Abundant	Poor	Aug. 2	Abundant.
White Bearded Spelt	Fair	July 28	Few	Fair	July 25				
White Club				Poor	July 15	None	Poor	July 25	Few.
White Crimea				Good	July 11	None	Poor	July 25	Abundant.
White Essex	Failure			Fair	July 28	Abundant	Failure		
White Flanders	Failure			Fair	July 15	Abundant	Failure		
White Glass				Failure			Failure		
White Llama	Failure			Fair	July 3	Abundant	Very poor	July 24	Abundant.
White Pearl	Failure			Failure			Failure		
White Russian	Failure			Fair	July 3	Abundant	Poor	July 24	Abundant.
White Sonora	Failure	July 28		Failure			Failure		

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OBSERVATIONS ON INJURY TO WHEAT BY THE HESSIAN FLY—Continued.

VARIETY.	1886.			1887.			1888.		
	Crop.	Harvest.	Flies.	Crop.	Harvest.	Flies.	Crop.	Harvest.	Flies.
White Velvet	Failure			Failure			Poor	July 25	Abundant.
Whittington	Poor	July 13	Few	Fair	July 8	Abundant.	Poor	July 25	Abundant.
Winter Eagle				Poor	July 25	Abundant.	Failure		
Winter Fulcaster				Good	July 25	None	Poor	Aug. 17	Abundant.
Winter (Rickenbrode)	Failure		Abundant.	Poor	July 15	Abundant.	Failure		
Yellow Noé	Poor	July 19	Abundant.	Fair	July 25	Abundant.	Poor	Aug. 7	Few.

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RESISTANT VARIETIES.

Volo and Washington Glass are the only varieties that have remained e from the Hessian fly. The latter, however, never yields well with . Several other varieties have a very good record. Especially free om the fly are the following:

arded Wheat from Missoyen.	Polish.	Diamond.
relle.	Blue Glass.	Egyptian Imported.
lestine.	Common March.	

The following varieties have had more or less fly, but never in undance:

arded Macaroni.	Greek Atlanti.	Nonette Lausanne.
Long-bearded Club.	Hunter's White.	Red Club.
yptian.	Improved Circassian.	Russian Red Bearded.
noese Winter.	Nicaragua.	White Club.

EARLY AND LATE VARIETIES.

One hundred observations on early and the same number on late rieties were selected from the large table above to compare their rela- n to Hessian fly injury. Of the one hundred early varieties only forty- e were badly infested, against sixty-seven of the late, an advantage the early varieties of over 20 per cent. The following table will give e data in more detail:

Flies.	1886.		1887.		1889.		Totals.	
	Early—Per Cent.	Late—Per Cent.	Early—Per Cent.	Late—Per Cent.	Early—Per Cent.	Late—Per Cent.	Early—Per Cent.	Late—Per Cent.
ne	18.3	3.3	23.0	13.8	4.0	0.0	17.0	7.0
y few	11.0	0.0	6.2	2.3	32.0	7.0	14.0	3.0
	41.4	31.3	12.3	16.1	28.0	25.0	24.0	23.0
ndant	29.3	66.4	58.5	66.8	36.0	68.0	45.0	67.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Comparing the same varieties on the basis of the yield, we get similar ults; 60 per cent of the early varieties give fair or good crops in spite the flies, while only 37 per cent of the late varieties do so. Below are figures in detail:

Crop.	1886.		1887.		1889.		Totals.	
	Early—Per Cent.	Late—Per Cent.	Early—Per Cent.	Late—Per Cent.	Early—Per Cent.	Late—Per Cent.	Early—Per Cent.	Late—Per Cent.
ure	0.0	10.3	0.0	0.0	0.0	0.0	0.0	3.0
poor	7.4	27.7	0.0	2.4	8.0	28.0	4.0	17.0	
	37.0	41.3	33.0	34.9	20.0	15.0	36.0	43.0
	51.9	20.7	23.0	37.2	48.0	5.0	37.0	26.0
	3.7	0.0	44.0	25.5	4.0	0.0	23.0	11.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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THE DATE OF PLANTING.

To settle the question of the best date for planting, it would be best if there were extensive parallel sets of experiments, but as there was considerable difference in date of planting in the different years, the results may be of some significance. The table below shows the average date of harvest, of planting, and the length of season of the three years:

Year.	Average Date of Planting.	Average Date of Harvest.	Average Length of Season.
1886	February 24	July 23	149 days.
1887	January 23	July 16	174 days.
1889	February 2	July 25	173 days.

The years 1887 and 1889 required practically the same length of time to mature the grain, and were only ten days apart in time of planting; but it is not these two years, but 1886 and 1889, that show parallel, whether measured by the crop or by the abundance of the flies, as the following tables will show:

Crop.	1886.	1887.	1889.
Failure	40 per cent	18 per cent	33 per cent.
Very poor	11 per cent	1 per cent	11 per cent.
Poor	26 per cent	29 per cent	33 per cent.
Fair	22 per cent	25 per cent	21 per cent.
Good	1 per cent	27 per cent	2 per cent.
	100 per cent	100 per cent	100 per cent.

Flies.	1886.	1887.	1889.
None	11 per cent	20 per cent	1 per cent.
Very few	6 per cent	4 per cent	21 per cent.
Few	33 per cent	14 per cent	27 per cent.
Abundant	50 per cent	62 per cent	51 per cent.
	100 per cent	100 per cent	100 per cent.

The conclusion to be drawn is that though there may be a decided difference between early and late sowing on a particular year, this difference is due to the peculiar conditions existing on that year; that early planting may be best on one year and late planting on another, and that no rule can be laid down.

In connection with these data it might be added that the crop of 1891, which was so peculiarly free from the Hessian fly, was planted much earlier than either of these years, being the tenth of November, 1890.

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THE USE OF GASES AGAINST SCALE INSECTS.

By F. W. Morse.

In the spring of 1887 the Agricultural Department of the University requested by Messrs. A. B. and A. S. Chapman, Mr. L. H. Titus, Mr. J. C. Newton, prominent orange growers of Los Angeles County, conduct experiments with the view of determining the efficacy of ain gases as insecticides—with special reference to the white scale, *ya Purchasi*. The work was intrusted to F. W. Morse, at that time harge of the Agricultural Laboratory, who carried on his investiga- s and experiments in the orange orchards at San Gabriel and pub- ed his results and conclusions in University Bulletins, viz.: Bulletin June 12, 1887; Bulletin 73, August 27, 1887; Bulletin 79, May 5, 8. Recent progress in the practical application of insecticidal gases made it unnecessary to reproduce some of these early investigations. ere were, however, certain points of the work of wide and permanent erest, and they are collated from the writings of Mr. Morse, as follows:]

he use of gases against scale insects has been long contemplated, and ous appliances have been suggested for the ready application of any acious gas. The ease with which gas penetrates to all parts of the naturally suggests its use as preferable to washes, which at best e many parts of the foliage and infested branches untouched, even n sprayed with the greatest care. In order that the gas may be an ient insecticide, it must be so poisonous that even when applied in ll quantities it produces fatal results, for in the application the air fined in the tent covering the tree dilutes the gas to a great extent. in, the gas must be capable of being generated quickly in sufficient ime. The record below shows that any one of the gases fulfilled e conditions to a satisfactory extent. Preliminary experiments with e others having shown their unfitness for the purpose, either on ount of expense or because of injury to the foliage, or imperfect on on the insects, their study was not pursued further.

GASES EXPERIMENTED WITH.

mong the gases used were chlorine, sulphuretted hydrogen, ammonia, on bisulphide, carbon monoxide, carbonic acid, hydrocyanic acid, carbolic acid vaporized by heat.

hlorine.—Some preliminary experiments were made in small vessels which this gas had been introduced. Some infested branches were wed to remain in them for times varying from five to thirty-five utes, without any noticeable effect being produced on the insect. nospheres more strongly saturated with the gas proved fatal to the ct in a short time. In other treatments extending over eighteen rs, with less saturated atmospheres, only a small percentage of the cts were killed. No decided effects were noticeable on the foliage ess the gas was very concentrated.

arbon Bisulphide.—A lime tree twelve feet in diameter at the top, treated with the vapor of two and one half pounds of sulphide of bon for forty-five minutes. At the end of this time the insects were ly, and during the treatment had crawled up and collected around

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a rope surrounding the tree, at the point where the gas was being injected from the hose. It proved that the gas thus used injures neither the insects nor the foliage. It is upon record, however, that in cases where the vapor has not been thoroughly diffused, but was allowed to flow down from an open vessel placed in the top of the tent, serious injury was done to the foliage at points where the undiluted vapor flowed down.

Sulphuretted Hydrogen.—Several treatments with this gas were made on a small scale, the application lasting from five to thirty-five minutes. The effects produced either with diluted or concentrated gas were similar to those produced by chlorine, except that even the concentrated sulphuretted hydrogen did not injuriously affect the foliage. An experiment in which a whole tree was treated in the tent for forty-five minutes, with quite concentrated sulphuretted hydrogen gas, showed clearly that the effect was far from being satisfactory; the insects for the moment were stupefied, but in the course of an hour and a half the majority of them were again moving about.

Ammonia.—The vapor from one pound and a half of strong ammonia water was applied to an eleven-foot lime tree for thirty minutes. The results were disastrous to the foliage; the leaves were all scalded, and in a few days all dropped from the tree, and even the newer growth of wood was injured. The insects, however, were not perceptibly harmed.

Carbon Monoxide.—Very strong hopes have been entertained by many for the successful application of this gas. Its apparent cheapness and easy production, when the necessary plant is once erected, would recommend it. Unfortunately our experiments show that it is not sufficiently effective to warrant its use. The gas was obtained by forcing air through a small furnace filled with red-hot charcoal, care being taken to cool and to measure the gas before applying it. No appreciable effect was noticeable after forty minutes. In a duplicate experiment, in which the charcoal was more strongly ignited and continuously introduced into the barrel for thirty minutes, only slightly better results were obtained.

Oxalic Acid.—It was thought that the production of carbon monoxide by decomposition of oxalic acid by heat, might be substituted for the previous method of generating this gas. One quarter of a pound of oxalic acid was ignited and the gases applied in a manner similar to that of the preceding experiment. Neither the insects nor the foliage was harmed in the least. This experiment has incidentally shown that the vapor of formic and oxalic acids, also produced during the heating of the latter, is likewise ineffective.

Carbolic Acid.—It has been suggested that carbolic acid vaporized by heat would prove fatal to the insect. A dose of half a pound of liquid acid was volatilized in the furnace, and the vapor blown into the vessel containing the infected branch. At the end of twenty minutes all the old insects were still alive, and some of the young ones, just molted, were moving about. An hour later the foliage appeared as if scalded.

Hydrocyanic Acid.—It was only with hydrocyanic, or prussic acid (generated by the action of sulphuric acid on potassium cyanide), that sufficiently fatal effects were secured to warrant a more thorough determination of the time of exposure and quantities of material which would produce the best results. Numerous experiments were carried on for this purpose, and it was shown that even small amounts were

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effective. It was also shown that even in these small quantities an injurious effect upon the foliage was produced. In the beginning of the experiments "mining cyanide" of potassium was used. It is a very impure material, and contains, along with the cyanide, a considerable amount of carbonate of potassium. For this reason many of the first treatments were practically ineffective.

Later treatments with pure cyanide were more successful in destroying the insects, but the foliage was proportionally injured. Treatments, varying in dose from four to twelve ounces of cyanide, and in time from fifteen to sixty minutes, showed that the effect produced on the foliage by longer treatment was not proportionally greater than that produced by short treatment. Neither was the effect of longer treatments proportionally more fatal to the insects. It was thus clearly shown that the gas mixture should be of considerable strength in order to secure rapid action.

The effect of the gas was so disastrous to the foliage that it became necessary to find some means of remedying this trouble. This was sought in applying a second gas, which might preserve the foliage. Sulphuretted hydrogen was therefore injected into the tent, together with the cyanide gas, both from the same generator, a portion of the sulphuretted hydrogen being introduced before the cyanide was generated. It was found that the insects appeared stupefied when the tent was raised, but large numbers revived in a few hours. The effect of the cyanide seemed therefore to have been decreased by the sulphuretted hydrogen. The foliage was not preserved, although not so badly affected as by treatments with cyanide alone.

Carbonic acid gas was next tried. Trees were treated with larger doses of cyanide than heretofore used, and the carbonic gas from one and one half pounds of carbonate of soda was at the same time introduced with these doses. The insects were killed, and the foliage of a twelve-foot tree remained unharmed, while that of a fourteen-foot tree, with the same amount of carbonic acid, was slightly injured. Thus it was shown that it would require one and one half pounds of bicarbonate of soda to preserve tree tops twelve feet in diameter, and that with this protection the deadly cyanide could be successfully used.

INJURY TO FOLIAGE.

It was plainly noticeable that under the influence of the direct sunshine much more burning took place. Trees which were treated in the forenoon of hot days, were burned mostly on the east side, and this injury to the foliage appeared always upon the side of the tree which was exposed to the sun at the time of the treatment. The injury was undoubtedly done while the tent was upon the tree, and did not result from burning after the tent was removed.

Trees which were treated early in the morning or late in the afternoon remained perfectly unharmed. In one case the temperature in the shade was about 92 degrees, while within and close to the sunny side of the tent the temperature reached 108 and 110 degrees.

This injury to the tree may be lessened somewhat by covering the frame with a cloth which will shade the tent; but it will be found more convenient to make the treatments with the gas in cooler seasons of the year, or in the cooler hours of the day. When injured by exposure to

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sun heat the leaves drop off, but without injury to the green, woody stems. Fresh shoots have appeared in the course of three weeks after the treatment.

The prospects of effective treatment of scale insects by this method are quite promising. The gas is not only deadly to the insects, but kills also the eggs, notwithstanding they are confined in the cottony cushion sac of the insect. The effect of the gas is equally deadly to the white as to the black and red scales.

It must not be understood that these experiments definitely settle the mode of operation and the size of the doses to be used. They are merely suggestive of a general plan which can be so perfected in the future that the application of this remedy to other kinds of trees and insects must be attended with good results. It simply remains for the ingenious cultivator to devise the necessary appliances for its use, on a small scale, on all sorts of fruit trees, shrubs, and plants.

It must not be forgotten that extreme care in the handling, both of this deadly gas and of the cyanide itself, is necessary. To inhale the one, or to taste or touch a wound with the other, may lead to serious consequences.

EXPERIMENTS ON THE CAUSE AND AVOIDANCE OF INJURY TO FOLIAGE IN THE HYDROCYANIC GAS TREATMENT OF TREES.

The investigations here recorded were made from time to time during November, December, and January of 1887–88, in order to find out what caused the injury, and likewise to explain the protective action of the carbonic acid used in the later experiments. The general manner of treatment, as applied on a large scale, was followed in each operation,* and suitable apparatus was devised for carrying on the details.

A barrel of about five cubic feet capacity was used as a chamber to replace the tent. A small bellows was used to produce the necessary circulation, and a glass bottle, into which was inserted a closed funnel holding the proper doses, served as a generator.

A small Woulff's (three-necked) bottle served the purpose of a "relay," where the gases could be mixed, or material for drying them inserted. The temperature was indicated by thermometers placed in the top of the chamber.

A half dozen orange branches set in pots, and a dozen well-potted orange seedlings were used to experiment upon. The former were used to obtain some preliminary measure of the quantity of materials to be employed in the later treatments.

* It should be noted that an essential point in the mode of operating, first practiced by me at San Gabriel in the spring and summer of 1887, was the use, at the suggestion of Professor Hilgard, of a pump or blower for the purpose of mixing the gases generated, with the air in the tent, by continuous circulation, thus avoiding injury from the effects of overdoses at some points, while leaving others without adequate treatment, as must inevitably happen where no such equalizing appliance is used. It was doubtless from this cause that experiments previously made by others (understood to have employed hydrocyanic gas) were not satisfactory.

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Table Showing the Arrangement of the Several Experiments; Numbered for Reference.

No. of Exp't.	Materials Used.	Method of Treatment.	Temperature—Deg. Fahrenheit.	Remarks.
1	Not treated			
2	Cyanide	Wet	60	
3	Cyanide+Carbonate	Wet	59	
4	Cyanide	Dry	58	
5	Cyanide+Carbonate	Dry	59	
6	Cyanide	Wet	58	
7	Cyanide	Wet	59	
8	Cyanide+Carbonate	Wet	59	
9	Cyanide	Dry	66	
10	Cyanide+Carbonate	Dry	67	
11	Cyanide	Wet	64	Sprayed.
12	Cyanide+Carbonate	Wet	63	Sprayed.
13	Cyanide	Wet	100	
14	Cyanide+Carbonate	Wet	103	
15	Cyanide	Dry	109	
16	Cyanide+Carbonate	Dry	106	
17	Cyanide	Wet	102	Sprayed.
18	Cyanide+Carbonate	Wet	97	Sprayed.
19	Ammonia determination			
20	Cyanide	Dry	59	
21	Cyanide	Dry	55	
22	Cyanide	Wet	54	
23	Cyanide	Wet	56	
24	Cyanide	Wet	56	
25	Cyanide	Wet	56	Gas dried.
26	Cyanide	Wet	63	
27	Cyanide+Ammonia	Wet	55	
28	Cyanide+Ammonia	Wet	67	
29	Cyanide+Ammonia	Wet	62	Mixed in chamber.
30	Formic acid+Ammonia		50	
31	Formic acid		53	

The second column shows the materials employed; the third indicates whether they were used in the solid condition (dry) or in solution (wet).

When operating in the "dry" way the salts were used in the solid form, and usually the gas was further dried and freed from ammonia by passing it through strong sulphuric acid. In operating in the "wet" way, *solutions* of the salts were used, and the gas was passed directly into the chamber, except in one or two cases, where the gas was subsequently dried. The fourth column indicates the temperature at which the air in the chamber was kept.

In No. 1 an orange limb was used, potted like the others, and left untreated, to serve as a check. It remained in good condition throughout the time of experimenting.

In the numbers following, the conditions were varied both by changing the manner of treatment and materials used. The doses used were larger in proportion than those used in the field-work, in which it was shown that small trees required proportionally larger doses than large ones.

In several cases the trees and the inside of the chamber were sprayed with water, to note the effect of the gas upon wet trees, and also to note that of water upon the gases themselves.

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PRODUCTION AND EFFECTS OF AMMONIA.

It is known that when *cyanates* are present in generating hydrocyanic gas, more or less *ammonia* is produced. In the materials used for these experiments this may have been the case. Furthermore, under certain conditions, ammonia may be produced in the treatment of simple cyanide with acid. Preliminary tests were made to demonstrate these facts, and to study the reactions when applied in various ways, as well as to determine the best mode of using the materials. For the intense scalding effects of ammonia upon the foliage had been noted in my former experiments, and it was conjectured that this gas, unintentionally produced, might be concerned in causing injury in cases not otherwise easily explained.

As previously reported, it was found impracticable to use the cyanide of potassium without first dissolving it, and that it was necessary to keep the carbonate of soda well mixed with the cyanide, so that the reaction upon both would occur at the same time. But it was further shown that the alkaline reaction of the gas, due to ammonia, is produced only when the solution, instead of the solid cyanide, is used; *rapid* addition of the acid to the dry salt, or *vice versa*, invariably produced an *acid* gas, while the *slow* mixing of the two materials in solution invariably produced decided *alkalinity*, often to a very harmful degree. The amount of ammonia was found to be variable, perhaps largely because a part was masked by the hydrocyanic acid produced during the violent action that takes place when the acid is added rapidly to the solution.

All the experiments with the dry cyanide alone showed but slight injury to the foliage, and a slight increased injury was noted on the plants treated with the cyanide *solution* alone. When the carbonate of soda was used with the cyanide in the solid form or in solution, the injury to foliage was in either case very materially lessened. Passing the gas through sulphuric acid produced results similar to those of the carbonate treatment, viz.: immunity to the foliage.

Indications have thus pointed toward ammonia as the cause of the injury—some direct experiments were made with this gas. In the first ammonia treatment the gas was separately generated and mixed with the hydrocyanic gas from an ordinary treatment, the mixed gases being conducted into the chamber.

The intensely acid action of the gas leaving the hydrocyanic generator at once turned to the alkaline, and so continued in the chamber, thus showing that a certain moderate excess of ammonia was present. Decidedly injurious effects upon the foliage were quickly noted.

In this experiment the ammonia and cyanide gases were mixed in the "relay." In order to leave more of the ammonia free to act upon the foliage, it was injected directly into the chamber, where the two gases were less intimately mixed. Upon circulating the gas, strong alkalinity prevailed in all parts of the apparatus, and the atmosphere about the tree was decidedly charged with ammonia. The results were very marked. In a short time the trees wilted; in ten days all the foliage was crimped up, and later all fell off. Even the wood of the more tender branches was noticeably affected.

As *formic acid* is often produced during the decomposition of a cyanide, an experiment was made to determine its effect upon foliage. A solution of the acid was boiled and the vapor was conducted into the

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chamber until quite a decided acid reaction was shown by the test of papers. No harmful effect was noticeable. Formic acid and ammonia were next separately introduced, the ammonia being in very slight excess. In this case also no noticeable harm was done.

INFLUENCE OF TEMPERATURE.

It is to be regretted that the normal temperature (50 degrees to 65 degrees Fahrenheit) during the experiments was much lower than that which would be met with in actual field work; and therefore the injury done to the seedlings would not be so marked as in the latter case.

An attempt was made to raise the temperature within the chamber up to that of a warm summer's day in the orange districts. The range of temperatures used was 95 degrees to 105 degrees Fahrenheit, but the outside temperature being low, as soon as circulation began, the moisture from the interior of the chamber given off during the rise in temperature was partially drawn in and condensed in the tubes during the circulation, and thus absorbed the ammonia, as well as part of the hydrocyanic gas.

Notwithstanding this partial removal of ammonia by absorption, the results showed that these high temperature treatments produced more injurious effects than similar treatments at lower temperatures.

CONCLUSIONS.

From the foregoing experiments we are led to believe that *ammonia* has been the fruitful cause of the injury to the trees subjected to the treatment under discussion. Under this view of the case, the beneficial effects of the use of carbonic acid gas would seem to be due to its power of neutralizing the ammonia, with the formation of carbonate of ammonium, when the two gases come together. And, furthermore, the failure of the carbonic acid to *completely* preserve the tree during the hot part of the day follows from easy decomposition, by heat, of the carbonate of ammonia, which does not occur during treatments at lower temperatures. Even the formate of ammonium, produced in a preceding experiment, would be decomposed in like manner, and some ammonia set free to act upon the foliage.

MODES OF PREVENTING INJURY.

There are, then, two means of averting the injury to foliage: *first*, by the use of the dry salt; *second*, by the use of proper appliances to absorb the ammonia as it leaves the generator.

In the first case, viz.: using the dry salt, only a minimum amount of ammonia is produced during a strong reaction. But it was shown that it is quite impossible to handle the dry salt so as to insure complete action of the whole dose; and, furthermore, the slowness of the action prevents the rapid injection of the gas into the tent. It should be injected rapidly, so that complete circulation of the gas about the tree may be established, and the maximum effect produced at once, so as not to make it necessary to increase the time of exposure.

In the second case, viz.: the use of the solution, the action is rapid, and the injection can take place immediately. But with the use of solu-

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tion, the trouble from formation of ammonia comes in; this can be obviated by the use of proper apparatus to absorb the ammonia as it leaves the generator.

The apparatus used in field work can be so modified that an absorbent of the ammonia may be inserted at the exit of the generator, and connected with the general circulation. Such an apparatus can be made of a cylinder filled with loose pumice stone, over which sulphuric acid is poured from time to time. By this means a large surface is exposed for the absorption, and it can be readily so arranged that, with slight trouble, the surface of the pumice stone can be resaturated with sulphuric acid.

This apparatus, if interposed in the tubes through which the general circulation takes place, would interfere with the rapid passing of the volume of air which is to accomplish the agitation within the tent. In order to avoid this obstruction, a secondary circuit may be connected with the general circulation, to be used only when the generator is to be cleared of the last portion of the hydrocyanic gas. The pressure of the gas alone, during its evolution, is sufficient to force its way slowly into the general circulation. Thus the general circulation and agitation remain independent of both generator and drying-chamber. The secondary circuit carries a volume of air from the blower through the generator and through the drying-vessel, and thence discharges into the general circulating pipe. This is accomplished by placing a hinged valve at the exit opening of the blower into the general circulating tube in such a manner that the current of air may be passed either forward or backward by reversing the motion of the blower. The air may be forced by the backward movement through the secondary circuit.

By application of either of the above methods the use of carbonate of soda can be avoided, and the work somewhat simplified. There will be far less residue in the generator, so that several treatments may be made without emptying the latter. Besides this, there will be a decrease in the expense through the omission of the carbonate and the correspondingly less amount of sulphuric acid required.

It will be necessary to demonstrate by further experiments whether the use of the cyanide alone will be so effective against the scale as when combined with carbonic acid. The best results of field experiments have accompanied the joint use of carbonate and cyanide, although it is maintained that the cyanide alone will produce as fatal effects upon the insect.

Some tests were incidentally made to note the effect of the gas upon the scale insects *Aspidiotus* and *Lecanium*. Branches of laurel and acacia infested with these scales were placed in the chamber during the treatment of trees at high temperatures. The effect, in some instances, was complete, while in others 90 per cent of the insects were killed, and the remaining 10 per cent still showed faint signs of life, and may have survived the treatment. Under the proper treatment, this gas remedy will undoubtedly prove as effective on these scales as upon the white scale, against which the remedy was originally intended to be applied.

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LIST OF PAPERS RECEIVED AS EXCHANGES, AND KEPT ON FILE IN THE READING-ROOM OF THE CENTRAL STATION.

[The papers in the following list are sent by the publishers in exchange for the bulletins, reports, and various publications of the Experiment Stations. We should be glad to extend the list in the direction of practical publications devoted in part or wholly to agricultural and horticultural work.]

FROM CALIFORNIA.

California, San Francisco.
California Fruit Grower, San Francisco.
Central Californian, Fresno.
Chino Valley Champion, Chino.
Citrograph, Redlands.
Fertilizing Gazette, South Riverside.
Four Corners, Wheatland.
Fresno Weekly Republican, Fresno.
Great Southwest, San Diego and National City.
L'Union Nouvelle, Los Angeles.
Orange Grower, Rialto.
Pacific Rural Press, San Francisco.
Pacific Wine and Spirit Review, San Francisco.
Petaluma Courier, Petaluma.
Press and Horticulturist, Riverside.
Redondo Beach Compass, Redondo Beach.
Rural Californian, Los Angeles.
San José Daily Herald, San José.
Santa Clara Valley, San José.
Weekly Gazette, San Francisco.
Weekly Times-Index, San Bernardino.
West American Scientist, San Diego.

FROM OUTSIDE OF THE STATE.

Agricultural Epitomist, Indianapolis, Indiana.
Agricultural Journal, Montgomery, Alabama.
American Grange Bulletin, Cincinnati, Ohio.
American Rural Home, Rochester, New York.
Baltimore Weekly Sun, Baltimore, Maryland.
Boston Weekly Globe, Boston, Massachusetts.
Fancier and Farm Herald, Denver, Colorado.
Farm and Fireside, Philadelphia, Pennsylvania.
Farm Journal, Philadelphia, Pennsylvania.
Farmer's Home, Dayton, Ohio.
Farm and Home, Springfield, Massachusetts, and Chicago, Illinois.

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Farmers' Review, Chicago, Illinois.
Holstein-Friesian Register, Boston, Massachusetts.
Horticultural Art Journal, Rochester, New York.
Hospodár, Omaha, Nebraska.
Landwirth, St. Louis, Missouri.
Louisiana Planter, New Orleans, Louisiana.
Mercantile Exchange, New York.
Mirror and Farmer, Manchester, New Hampshire.
National Provisioner, New York.
National Reformer, Houston, Texas.
New Dairy, New York.
Northwest Horticulturist, Tacoma and Seattle, Washington.
Orange Judd Farmer, Chicago, Illinois.
Popular Gardening and Fruit Growing, Buffalo, New York.
Poultry Bulletin, New York.
Practical Farmer, Philadelphia, Pennsylvania.
Review and Farmer, Pueblo, Colorado.
Southern Cultivator and Dixie Farmer, Atlanta, Georgia.
Texas Journal of Horticulture, Tyler, Texas.
Vick's Illustrated Monthly Magazine, Rochester, New York.
Vorwärts, Toledo, Washington.
Western Breeder, Beattie, Kansas.
Western Resources, Lincoln, Nebraska.

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AGRICULTURAL EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA,

IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

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1891.	To receipts from the Treasurer of the United States, as per appropriation for the year ending June 30, 1891, under Act of Congress, approved March 2, 1887		$15,000 00
June 30—	By buildings	$179 05	
	By chemical apparatus and supplies	32 61	
	By furniture	165 30	
	By fencing and drainage	174 29	
	By freight and expressage	70 78	
	By incidental expenses	229 05	
	By labor	5,016 83	
	By live stock	500 00	
	By postage and stationery	32 50	
	By printing	22 50	
	By salaries	5,350 86	
	By supplies	2,035 35	
	By tools, implements, and machinery	424 06	
	By traveling	497 85	
	By water supply	268 97	
	Totals	$15,000 00	$15,000 00

We, the undersigned, duly appointed members of the Finance Committee of the Regents of the University of California, do hereby certify that we have examined the books and accounts of the Experiment Stations of the University of California, for the fiscal year ending June 30, 1891; that we have found the same well and correctly kept and classified as above, and that the receipts for the time named are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
ALBERT MILLER,
I. W. HELLMAN,
Finance Committee of the Regents of the University of California.

I hereby certify that the foregoing statement, to which this is attached, is a true copy from the books of account of the institution named.

J. H. C. BONTÉ,
Secretary of the Board of Regents.

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AGRICULTURAL EXPERIMENT STATION.

REPORT OF WORK

OF THE

AGRICULTURAL EXPERIMENT STATIONS

OF THE

UNIVERSITY OF CALIFORNIA,

For the Year 1891-92.

BY E. W. HILGARD,
Professor of Agriculture and Director of the Stations.

BEING A PART OF THE REPORT OF THE REGENTS OF THE UNIVERSITY.

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REPORT OF THE PROFESSOR OF AGRICULTURE AND DIRECTOR OF THE EXPERIMENT STATIONS

TO THE

PRESIDENT OF THE UNIVERSITY.

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LETTER OF TRANSMITTAL.

President MARTIN KELLOGG:

DEAR SIR: I transmit herewith for publication a report of the work of the Agricultural Experiment Stations of the University of California for the fiscal year 1891–92. As a rule the report includes investigation and experiment pursued up to July 1st of the latter year, but as the publication of the record has been somewhat delayed, there has been introduced in a very few instances allusion to later investigation undertaken for corroboration of the results of earlier researches in the same line. The work was accomplished under the personal supervision of Director Hilgard, and was practically completed before his year of absence began. The preparation of this report, including both the exposition of the chemical work, which appears under his signature, and the editorial revision of all parts of the document, has devolved upon Assistant Professor R. H. Loughridge, and it has been discharged with great skill and fidelity.

One of the most obvious features of the report is the amount of work undertaken in response to public demand. Since the establishment of the outlying stations, and the quickened interest everywhere manifested in the scientific investigation of agricultural methods and materials, the demands upon this Station for particular tests and analysis have vastly increased. To minister to this demand is so clearly a public service, or at least a popular service, that we have continued, as heretofore, to give much time to special inquiries as suggested by our correspondents. Fortunately, as this report shows, many matters of individual interest have wide bearings, and the results secured by investigation increase our data from which general deductions can be made.

Though, however this report reflects this characteristic of our work, it indicates also that systematic lines of investigation, like those reported by Messrs. Jaffa and Colby, are rising to greater prominence, and will still further be developed in the future. This will be possible, both by means of our improved laboratory equipment and facilities for field experiment. The outlying stations, of which very significant notes are given in this report by Inspector C. H. Shinn, are now reaching the point of returning valuable results through comparative observation of various growths undertaken under different conditions of soil and climate, and with different treatment under similar conditions. Already the local establishments are being visited by many people for the express purpose of learning by observation the particular adaptations of the regions to different economic growths; and the advantages of maintaining in one place, and open to public inspection, wide collections of these growths, is being freely commented upon by discerning people. Enthusiastic persons have declared that many single demonstrations thus early made are each worth more to the regions than the cost of the establishments. Such testimonials are of course encouraging, as betokening the public approval of the efforts which are being put forth; but, though we have full confidence in the theory of local experi-

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mentation upon which the several foundations were made, it is evidently too soon to attempt an estimate of the practical outcome. The demonstration of this is just at its beginning.

This report gives intimation of the indirect benefits secured for Experiment Station work by the increase of the teaching staff of the College of Agriculture through the Morrill Aid Fund. One indication is seen in the important contributions to entomological literature by Assistant Professor Woodworth. In addition to his well attended lecture and laboratory classes, he constantly pursues investigations in economic, structural, and systematic entomology, especially upon lines most likely to facilitate instruction and to aid the student who endeavors to pursue his own way into a most difficult subject. Professor Woodworth's synopsis of "Diseases of Cultivated Plants" and of "Families of Insects" will be found of great value to the practical agriculturist and to the student of plant and insect life. It is anticipated that the synopsis of "Families of Insects" will also be of much assistance to teachers of economic entomology.

Another phase of work made possible by the Morrill Aid Fund is that involved in the holding of Farmers' Institutes under University auspices. A very encouraging beginning has been made, and this form of University extension, through the College of Agriculture, meets with marked popular approval in many parts of the State. I have now in preparation a special report on Farmers' Institutes in California, which I hope soon to complete and submit for your approval.

Very respectfully,

E. J. WICKSON,

Associate Professor of Agriculture, and Acting Director of University Experiment Stations.

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EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA, 1892.

CENTRAL STATION (Berkeley, Alameda County).

E. W. HILGARD, Ph.D., LL.D. (Professor of Agriculture), Director and Chemist.
E. J. WICKSON, M.A. (Associate Professor of Agriculture, Horticulture, and Entomology), Superintendent of Agricultural Grounds.
E. L. GREENE, Ph.B. (Associate Professor of Botany), Botanist.
R. H. LOUGHRIDGE, Ph.D. (Assistant Professor), Agricultural Geologist and Agricultural Chemist.
C. W. WOODWORTH, M.S. (Assistant Professor), Entomologist.
M. E. JAFFA, Ph.B. (Instructor), First Assistant Chemist in Agricultural Laboratory.
*L. PAPARELLI, Lic. Agr. (Instructor), Assistant in charge of Viticulture and Olive Culture.
GEO. E. COLBY, Ph.B. (Instructor), Second Assistant Chemist in Viticultural Laboratory.
C. H. SHINN, A.B., Inspector of Stations.
EMIL KELLNER, Foreman of Station Grounds.
F. T. BIOLETTI, Foreman of the Viticultural Cellar.
A. V. STUBENRAUCH, Clerk to the Director.

SIERRA FOOTHILL STATION (near Jackson, Amador County).

R. C. RUST, Patron; Jackson.
GEORGE HANSEN, Foreman; Jackson.

SOUTHERN COAST RANGE STATION (near Paso de Robles, San Luis Obispo County).

GEORGE R. ADAMS, Patron; Paso Robles.
†R. D. CRUICKSHANK, Foreman; Paso Robles.

SAN JOAQUIN VALLEY STATION (near Tulare City, Tulare County).

A. J. PILLSBURY, Patron; Tulare City.
JULIUS FORRER, Foreman; Tulare City.

SOUTH CALIFORNIA STATION (near Pomona, Los Angeles County).

RICHARD GIRD, Patron; Chino.
K. MCLENNAN, Foreman; Pomona.

VITICULTURAL STATION (under private auspices).

EAST SIDE SANTA CLARA VALLEY STATION; Mission San José, Alameda County. John Gallegos, Patron; Mission San José.

* Resigned June 1, 1893. † Resigned February 1, 1893.

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RECORD AND DISCUSSION OF WORK IN THE GENERAL AGRICULTURAL LABORATORY.

EXAMINATIONS AND ANALYSES OF SOILS, WATERS, FRUITS, ALKALI, AND MISCELLANEOUS SUBSTANCES.

This division of the report embraces the analytical work of the chemists in the laboratories during the past year, a large part of their time being also occupied in the instruction of special students in analytical methods of agricultural and viticultural chemistry; also in lectures on agricultural and viticultural chemistry in the class-room.

In the agricultural laboratory Mr. Jaffa has been engaged in the analysis of waters, both general and sanitary, fertilizers, alkali, fodder stuffs, sugar-beets, ramie, and in the full analysis of important soils. The work on fodder stuffs has been but just begun and will be continued so as to embrace all of those produced in this State.

In the viticultural laboratory Mr. Colby, in addition to the analyses of musts and wines for the Viticultural Report, has under examination many varieties of figs, apricots, prunes, and citrus fruits. These will be continued during the next season.

In the special laboratory of my own much time has been given to the examination of soils, waters, rocks, minerals, etc., sent in from all parts of the State, and in the analysis of alkali waters and soils of the Tulare Experiment Station. The mechanical analyses of characteristic soils, and the determination of their capillarity, is going forward as rapidly as the soil elutriator will permit. The water-holding power or water capacity of some two hundred soils has been determined, with a view of the study of the causes that govern that power, whether the presence of certain proportions of fine ingredients such as clay and fine silts, the presence of ferric hydrate, of humus, or of some other substance, or all of these; the results will be given as soon as practicable.

The discussions of the analytical results in the following report on soils and waters are chiefly from the pen of Professor Hilgard, in answer to the letters accompanying the samples.

A few of the analyses here given were made previous to the last year, and should have appeared in the last report, but were overlooked.

R. H. LOUGHRIDGE.

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I. ANALYSES OF SOILS.

A. SIERRA FOOTHILLS.

Honey Lake Valley.

The magnificent valley, of which Honey Lake forms the lowest portion, deserves more than a cursory description. But inasmuch as the investigation of its soils is only begun, and will not be completed in time for the issuance of the present report, only generalities can be given here in explanation of the data given below.

The Honey Lake Valley is only a portion of a much more extensive basin which originally embraced not only the greater part of Long Valley, but the entire low country to and beyond Pyramid Lake, Nevada; itself only a small portion of the great lake area now known to geologists as Lake Lahontan, covering in past ages the greater part of Nevada, and a part of western Utah. In its recession by evaporation, this lake left numerous minor basins, partly with, partly without, permanent outlets. Of the latter, Honey Lake is one; and as a consequence its waters are quite alkaline when they exist at all; but within the experience of the present generation its bed has been quite dry and covered with a white crust of "alkali." This lake-bed is mostly surrounded by a very definite shore-line, beyond which it has manifestly not advanced within the memory of man; on the leeward (north) side, moreover, it is, near its eastern end, bordered by a conspicuous ridge of sand hills or dunes, the result of wind-drift. The mountains descend rather abruptly to the valley level on both sides, those on the south side being snow-flecked even in mid-summer, and suggesting the cool nights with which the valley is blessed at all times. A short ridge with gentle slopes subdivides the upper valley into two branches, of which the longer terminates at Susanville against an abrupt ridge of eruptive rock. The remarkable boiling springs, and the low ridges formed at several points by calcareous tufa originally deposited by their gigantic predecessors, speak of volcanic activity at no very remote time.

The width of the lake-basin proper varies from 12 miles at the west end to 6 miles at the east, including the spit of land between the two areas; its length is 12 miles from the mouth of Susan River, its main feeder, to the junction with Long Valley Creek. From the latter point, however, the valley extends back (westward) quite 30 miles to where Susan River emerges from the mountain country; a portion consisting of rolling uplands, while a varying, but always considerable, proportion is valley land proper, partly naturally moist, partly low enough to be easily irrigated.

The lands of the latter character consist essentially of two distinct soil qualities. One is the heavy black adobe of the Susan River delta, profusely fertile intrinsically, but largely overflowed during spring floods, and thus far occupied chiefly as natural hay grounds or meadows, and collectively known as "the tules." Outside of these the valley soils

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are either sandy or silty, the latter mostly of a whitish tint, and covered with a mixed growth of "green sage" and greasewood, the latter indicative of a certain degree of impregnation with alkali.

Of the profuse and lasting fertility of the "tule lands," there is no question both from the standpoint of experience and science. Their analysis has not yet been made; the only drawback to their cultivation is their predominantly undrained condition, which leaves a large proportion of the area covered with weeds and sedges, instead of nutritious grasses and clovers that occupy the higher portions, and prove beyond cavil what would be the result of a rational system of drainage and the exclusion of late overflows.

The whitish silty soil constitutes most of the lake border lands outside of the Susan delta at the western end of the lake. It is loose and friable, easily tilled, and contains scarcely any gravel or coarse sand; occasional coarse particles found consist usually of lime concretions formed in the soil. The surface soil is grayish and scarcely changes to the depth of 15 to 18 inches; it then becomes more yellowish, but only a trifle heavier, to depths of 4 to 5 feet. Borings show that it continues almost unchanged to over 20 feet in the neighborhood of Amedee.

No. 1548 is from average land about 2 miles west from Amedee; vegetation, only greasewood (*Sarcobatus vermiculates* and the flat-leaved variety). The sample was taken to the depth of 12 inches.

To the westward of the lake, beyond the delta, the country rises gradually into undulating uplands around the Susan Meadows, to meet the incoming of Willow Creek from the north; a broad, fertile, alluvial tract surrounds the junction. The uplands are quite sandy, sometimes gravelly; but the heavy growth of gray sage that covers most of this land speaks of its good productiveness, if irrigated. Most of it is above any irrigation system projected thus far; but it seemed of interest to determine whether its cultivation would be likely to repay the cost of irrigation.

No. 1561 is a representative sample of this kind of land. It was taken to the depth of 12 inches; at that depth there is little change in tint, but it becomes more yellowish farther down, and apparently more coarsely sandy. The coarse portion is at many points conspicuously white quartz gravel, not much rounded. The soil is of a light dun or fawn color, and may be termed a sandy loam, which becomes barely plastic on wetting, and would till easily at all times.

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Honey Lake Valley Land, Lassen County.

	No. 1548. Soil 2 Miles West of Amedee.		No. 1179. Soil Northeast of Amedee.		No. 1561. Sagebrush Soil, opp. Susan Meadows.	
Coarse materials >0.5mm		1.33		40.00		17.00
Fine earth		98.67		60.00		83.00
Analysis of Fine Earth.						
Insoluble matter	56.60	69.79			80.91	87.51
Soluble silica	13.19				6.60	
Potash (K_2O)		.91		.85		.28
Soda (Na_2O)		.94		.49		.27
Lime (CaO)		6.94		4.78		.92
Magnesia (MgO)		2.09		1.80		.39
Br. ox. of manganese (Mn_3O_4)		.02				.05
Peroxide of iron (Fe_2O_3)		4.86				4.71
Alumina (Al_2O_3)		5.29				4.06
Phosphoric acid (P_2O_5)		.17		.12		.06
Sulphuric acid (SO_3)		.15				.08
Carbonic acid (CO_2)		4.71		3.76		
Water and organic matter		3.87		2.47		1.61
Totals		99.74				99.96
Humus		.29				.33
Ash		.94				.38
Soluble phosphoric acid		.04				.03
Silica		.90				.28
Hygroscopic moisture (absorbed at 15° C.)		6.32				2.64

The analysis of the silty soil (No. 1548) shows it to be of high agricultural value—it is highly calcareous, and very fully supplied with both potash and phosphates. As its color indicates, it is quite poor in humus, yet not more so than many of the first-class fruit soils of South California. The high content of soda shown in the analysis speaks of its one fault, namely, a tendency to alkalinity, which is sometimes developed in low ground to the extent of reducing its vegetation to greasewood alone, and forming alkali crusts.

The land is, however, too valuable to be allowed to lie idle on that account. It is eminently worthy of having applied to it, where necessary, the several remedies for alkali fully described in a special publication of this Station, which can be had on application. Among the first needs for this purpose will be a supply of land plaster for the neutralization of the carbonate of soda—"black alkali"—which forms a prominent ingredient of the lake water as well. Where this kind of soil intermingles with the black delta adobe, the latter is more easily tillable, and should be profusely productive.

As to the sandy soil, No. 1561, it is not nearly as "strong" as the silty soil; yet considering its high content of lime, and the consequent availability of its mineral plant food, as well as its great depth, it will be eminently available for fruit culture. Hence it will, with other slope lands, undoubtedly be brought under culture ultimately by the aid of irrigation from the high-lying supply of Eagle Lake, whenever this shall become available.

The lands of lower Long Valley, so far as they have come under observation, appear to be intermixtures, in varying proportions, of the whitish silt soil with the sandy lands of the higher ground just described. Their dense, vigorous growth of gray and "hop" sage promises high productiveness under irrigation.

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The several enterprises now being pushed toward assuring an adequate water supply for the Honey Lake region will doubtless soon bring these lands into active demand for cultivation. (E. W. Hilgard.)

Red clay soil of a valley one half mile in width, in the foothills 3 miles east of Chico; a lava formation bordering the valley on either side; from C. L. Stetson, Oroville, Butte County. The soil is a heavy red adobe, which does not yield readily to water. Similar soils of the region have proven so very poor in potash and phosphoric acid that, with the additional drawback of being extremely hard to work, we may conclude that this land would hardly justify the labor and expense of cultivation.

Red soil, from Browns Valley Irrigation District, Yuba County; sent by Peri E. Allen, San Francisco. The soil is stiff clay and of a bright red color, from the presence of much iron oxide. There is only a trace of phosphoric acid, and therefore in continued cultivation the application of phosphates would be necessary to keep up fertility.

Slate soils, from 2½ miles northeast of Carbondale, Amador County, on east side of Willow Creek; sent by H. C. Barrow.

No. 1, a red hill soil, made up of 53 per cent of clay, 18 per cent of fine earth, and 29 per cent of coarse sand. No. 2, red hillside soil, very similar to the other. Both taken from 3 to 18 inches deep. Rotten slate rock, standing upright in layers, underlies every part of the land, at from 3 to 48 inches. The vegetation is chiefly live oak, from 6 to 24 inches in diameter, with a few pines.

"The prominent feature of the slate soil and the subsoil is the very large percentage of potash, wherein it competes with the richest soils of the San Joaquin Valley, although probably the potash is not in as available a form as in the valley soils. The amount of lime, though not very high in the surface soil, is abundant in the subsoil. Direct determination shows 0.04 per cent to be in the form of carbonate. The percentage of phosphoric acid, as usual in California upland soils, is not high, but very largely in the soluble form. The amount of humus is rather low, perhaps in consequence of the oxidizing influence of the very large amount of finely diffused iron oxide. The moisture absorption is that of the most desirable upland loams, increasing in the heavier subsoils. This red slate soil is the one most generally approved, especially for fruit culture; largely because even when it is shallow, cultivation soon deepens it by the disintegration of the bedrock, into which, since it stands steeply on edge, the roots of trees and vines readily penetrate, obtaining both moisture and mineral plant food. It is a marked peculiarity of this typical red earth of the placer mines, that it will assume the functions of a soil at once, even when taken from depths of 7 to 12 feet. Hence it is that the lands worked over by the early miners, where they have not been subsequently overrun by gravel, or denuded of their red soil, soon become covered with the natural vegetation of the region." (Report of Agr. Expt. Stations, 1888–89, pages 55 and 82.)

Valley soil and subsoil, Yosemite Valley, Mariposa County; from Geo. C. Thomas. A dark sandy loam, with reddish subsoil. The soil has numerous rounded, irregular concretions of bog iron ore; smaller grains, partly of light pearl quartz, partly rounded and angular scattered grains, and of mica.

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B. GREAT VALLEY.

Soils, from John Holm, Los Baños, Merced County; two soils, with their subsoils, taken 400 feet apart.

Soil A. Black adobe in small lumps, which do not yield readily to water. The subsoil sample is of very hard lumps of adobe.

Soil B. Situated 5 feet higher than the other, lighter in color, but also very stiff and unyielding to water. Its subsoil is similar in nature to that of A.

If the sample of soil A was taken when not too wet and compacted, and represents its natural condition, it is certainly not a desirable soil for fruit of any kind; but apricots and plums, as well as blackberries, might do fairly well on it, if well cultivated.

Soil B is better in every respect than the other; still it has quite a heavy subsoil, and is very unlike the soils on which Muscats have usually been successful for raisin culture. Almonds would probably not thrive well; prunes will doubtless do, and so will figs, and possibly pears; the latter will largely depend upon the subsoil deeper down than the sample goes. The land is really best for field cultures.

Soil and subsoil, from Villa Nova ranch, 10 miles southeast of Los Baños, Merced County; sent by J. L. Dickenson. Both soil and subsoil, taken to 18 inches depth, are a dark calcareous adobe, free from black alkali, and rich in potash and phosphates. The vegetation is greasewood. If deep and thorough tillage is practiced it is susceptible of profitable cultivation. Such heavy soils can be used only for particular kinds of fruits, such as the fig, plum, and, if there is no hardpan underneath, pears; grapes will also do, if intended for wine or table, but not the raisin grape. The soil is also adapted to the ramie, grain, and alfalfa, if sufficient depth of tillage is given.

Soils, from Dos Palos, Merced County; three samples; sent by B. Marks. One is a dark loam, with very little coarse sand. It is but slightly calcareous, without alkali, and with a fair per cent of phosphoric acid. The other two samples are of calcareous adobe, containing more phosphoric acid than the first; no black alkali. Another sample of black adobe contains white particles of gypsum and some white alkali. It is composed of 68 per cent of fine earth and 32 per cent of sand.

Soils, from Las Pasas Vineyard Co.'s land, Fresno; sent by G. F. Wilson, San Francisco. Three samples, taken from spots 10 to 15 acres in extent, where young vines do not thrive. An examination shows the presence of more or less alkali in each. In the worst one there is 1.193 per cent of soluble salts, consisting of 0.960 per cent of chloride of sodium, 0.004 per cent of carbonate of soda, and 0.229 of sulphates of soda and potash. The alkali present is of a mild character, and with thorough tillage not likely to harm the vines directly. The real cause of the trouble is probably that the tract is underlaid by a sheet of hardpan, which causes the alkali to come up, and will in time make more serious trouble. The remedy is to break up the hardpan, either by shots put in at proper intervals, by prying with crowbars, or by laying underdrains. The injury caused by the hardpan is that it compels the roots to remain at a shallow depth, and that the rise of the water every winter will bring up more alkali, which will stay there and gradually increase.

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Soils and subsoils, from the Duhring tract, 7 miles southeast of Fresno; sent by W. R. Nutting, San Francisco.

No. 1. Soil, subsoil, etc. (four samples), from the center of the north line of the half section; 6 feet to hardpan. This contains 78 per cent of coarse material, comprising in part grains of magnetic iron, mica, feldspar, and actinolite, 13 per cent of fine sand, and about 9 per cent of clay and fine earth. Its subsoil is not rich in phosphates, but equal to other Fresno lands. It is entirely free from alkali.

No. 2. Soil, subsoil, etc. (four samples), from near the center of the north line of the half section; 6 feet to hardpan. Its subsoil is rather deficient in phosphates. The lower portions at 40 to 60 inches are calcareous.

No. 3. Soil, subsoil, etc. (three samples), from shallow boring on the land; they are slightly alkaline. There is a fair amount of phosphoric acid present in the subsoil. This soil resembles in some respects the "white ash" soil of the region; is more substantial than the soils Nos. 1 and 2, and will produce more freely and last longer, other things being equal.

Taking the tract as a whole it may be said that in its present condition as to water level, it is best adapted to alfalfa or other field crops, which will doubtless yield excellent results. If the water level be lowered by a drainage-ditch, properly laid, the amount of available soil mass can be doubled, and the land made as good as any of the region. Such a ditch would also do away with all danger from a rise of alkali by irrigation. The rise of bottom water as the result of ditch leakage is the direct cause of the appearance of alkali on many of the lands of the Fresno region.

Light soil, from Oleander, Fresno County; sent by A. S. Twogood. An examination shows the presence of some "black alkali" (carbonate of soda) and indicates that a dressing of gypsum on the spots in which it appears, and especially around each vine or tree, would be advisable, at the rate of 800 pounds per acre, putting a little around each trunk for protection. If there is no hardpan, the gypsum and good, deep tillage is about all that will be needed on this light soil to prevent damage; only the rooting of cuttings must not be undertaken near the affected spot.

Soils, from near the head of Centreville Bottoms, Fresno County; sent by J. D. Mathews, of Newcastle, Placer County.

Reddish and cultivated soils 5 to 6 feet deep and underlaid by coarse gravel.

Reddish, "hog-wallow" soil, underlaid by a soft hardpan at 30 inches. The latter is 15 inches thick and overlies a firmly cemented gravel. This land lies 5 feet higher than the other and 15 to 20 feet above the river bottom.

This tract of red land reaches to Centreville. The hog-wallow soil comprises some coarse material, chiefly of rounded, clear quartz grains, with some angular and scattered grains of feldspar.

Analyses of soils from this red land of the valley border are given on page 127 of the Report of Experiment Stations for 1888–89, and show the presence of ample amounts of potash and lime, but a small percentage of phosphoric acid. "Fruit culture would seem to be their special adaptation, from their friable nature, great depth, and good drainage."

Soil, from Central Colony, Fresno; sent by Miss L. H. Hatch. The

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soil is grayish, and contains black alkali, which has removed the humus and rendered the soil unthrifty. It is otherwise a very good soil, containing an abundance of potash and phosphoric acid. It is advised to use gypsum and vegetable mold, and drain well.

Soil, from 14 miles southwest of White's Bridge, Fresno County; sent by G. W. Andrews, San Francisco. The soil is a soft alluvial loam, slightly calcareous but free from black alkali. There is a little Glauber's salt present, but the soil is a very good one.

Soil and subsoil, from the Chapman place, 6 miles southwest of Fresno; sent by H. A. Redfield, Oakland. The soil is a light loam, dark in color, and made up of 46.4 per cent of fine earth and clay, and 53.6 per cent of coarse material. The subsoil is more sandy, having but 21.2 per cent of fine earth. There is said to be no change in its character to a depth of 60 feet. Water rises to within 20 feet of the surface. Like most of the soils of the San Joaquin Valley, the soil is a strongly calcareous one, and there can be no question about its being well supplied with potash from the nature of the material, while its content of phosphoric acid is satisfactory. It is undoubtedly admirably adapted to the culture of fruits, and notably to that of the raisin grapes, to which the climate is also probably favorable. There is not the slightest indication of alkali in the samples, and, unless brought up by the rise of bottom water, there is no reason why there ever should be any in so well-drained a soil.

Soil and subsoil, 6 miles from Tulare Lake; sent by the Parker-Ford Land Company, San Francisco. Both samples are of a light loam character, dark gray in color, to a depth of a foot as taken. There is some alkali present, but only of the mild, white variety. The adaptability of the land for fruits and vines depends upon the depth to bottom water, the nature of that water, and the character of the subsoil for several feet from the surface.

Soil, from 12 miles southeast of Bakersfield, Kern County, at an elevation of 150 feet above the town; the land slopes westerly; sent by L. L. Dixon, San Francisco. The soil is a loose loam, full of gravel and sand—quartzose. It has no vegetation, except small cactus, about 6 to 8 inches high; in winter a light growth of grass. For so sandy a soil it contains a fair amount of phosphoric acid. There is no black alkali present.

Soils and subsoils, from Hanford, Tulare County; six samples, sent by Mr. McQuiddy. The soils are light and gray in color, apparently river alluvium. The subsoils are in part very heavy, yield readily to water, and are somewhat calcareous. The lighter subsoils are more unyielding when wet, and not so easy tillable. The percentage of phosphoric acid in these soils is very fair for all. As to adaptation, it is probable that figs and plums would do especially well—prunes not quite so well. It is doubtful that Muscat grapes would do well on either soil, but they might be tried on the lighter one. Shipping grapes would do well, and so would wine grapes of the proper kinds for the climate; that is, port and sherry grapes. Peaches, almonds, cherries, and nuts will find this soil uncongenial. Quinces would flourish, and apples and pears will do well with good cultivation. Of course alfalfa will do finely when a stand is obtained. The soil is rather poor in vegetable matter, and a few crops of alfalfa would help it in this respect.

Soils, subsoil, and underclays, obtained from the section of a well 24

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feet deep, on Rancho Palma, Sec. 17, Miramonte, Kern County; sent by Geo. A. Raymond. The section shows:

Fine sediment	16 inches.
Moderately heavy swamp deposit	46 inches.
Calcareous hardpan	28 inches.
Clayey silt	24 inches.
Brownish clay, quite plastic	12 inches.
Fawn-colored silt or fine sand	14 feet.
Coarse sand at bottom.	

If the hardpan were nearer the surface it would be advisable to break it up with giant powder for fruit trees. But the first 5 feet of the soil is so rich, that anything but a pear tree will be satisfied with it for a long time. Grapes would probably push their way through the hardpan. But it is a hard question to settle from samples.

Soil, from Sec. 7 on same land, contains some black alkali, enough to render the use of some gypsum in cultivation advisable. If used for orchard, it would be sufficient to put the plaster around the trees.

Soils, from the old bed of Kern Lake, Kern County; sent by W. J. Doherty, Bakersfield. "Three of the samples were taken from the center of the lake, at depths of 1, 2, and 3 feet, respectively; the other about a mile from the center. The lake has been dry about two years. On some of this land barley fails to sprout, although the soil has remained moist for some time from recent rains."

The soil from the center of the lake (on which barley does not sprout) is for the entire 3 feet a stiff, bluish clay, yellowish in places. It is not calcareous, nor is there black alkali present in it, though the water of the lake used to be very "black." There is, however, 1.67 per cent of white alkali in the surface soil, which perhaps is the cause of the trouble. Good drainage, by which this may be leached out, is the remedy.

The other soil is a gravelly loam, free from alkali, and the barley can, of course, sprout without trouble.

C. COAST RANGE.

Soils, from 2 miles northeast of Willits, Mendocino County; sent by E. F. Swortfiguer, San Francisco. "A large part of the land from which the samples were taken lies about 22 miles inland from the ocean, and is well sheltered on the west from the coast winds by intervening ridges, covered with a heavy growth of redwood timber, and from cold winds from the north by a heavy growth of pine and fir. The elevation is about 2,000 feet above sea-level." They were taken to a depth of 22 inches.

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Soils from near Willits, Mendocino County.

	No. 1459. Valley Soil, Home Ranch.	No. 1460. Hill Soil, Hammond Ranch.	No. 1461. Soil, Elevation 2,000 feet, Young Ranch.
Coarse materials>0.5mm	50.00	50.00	50.00
Fine earth	50.00	50.00	50.00
Analysis of Fine Earth.			
Insoluble matter	55.55	59.50	69.20
Soluble silica	13.56 } 69.11	9.33 } 68.83	5.57 } 74.77
Potash (K_2O)	.76	.61	1.14
Soda (Na_2O)	.04	.05	.09
Lime (CaO)	.29	.30	.38
Magnesia (MgO)	1.03	1.02	1.61
Br. ox. of manganese (Mn_3O_4)	.06	.04	.05
Peroxide of iron (Fe_2O_3)	8.80	12.77	5.53
Alumina (Al_2O_3)	11.95	6.97	9.74
Phosphoric acid (P_2O_5)	.04	.06	.06
Sulphuric acid (SO_3)	.04	.03	.04
Water and organic matter	7.45	9.25	6.30
Totals	99.57	99.93	99.71
Hygroscopic moisture (absorbed at 15° C.)	5.27	5.89	4.47

These soils, while of excellent quality as a whole, are rather poor in lime as compared with others of the State, though not deficient. They share with other California soils a large proportion of potash, and a rather low one of phosphoric acid. The latter is doubtless the first deficiency that will make itself felt, unless it be that of humus, which (as the soil was taken to 22 inches depth instead of 6 or 8) could not be determined in the samples.

As regards field crops, roots, and not grain, will hold out longest on these soils. They all contain so much gravel that cultivation will not be difficult, and roots, with fair tillage, will find no difficulty in developing. Their moisture absorption is satisfactory.

As to fruits, grapes, apples, and pears would seem the best suited to the soils; stone fruits will doubtless do well also, but with heavy crops will soon require fertilization with phosphates. The hill soil would seem specially adapted to peaches and high-class wines, and almonds, if the climate permits. Apricots should do well, especially on the Young ranch, and on the valley land if not liable to late frosting.

Judging by the large size reached by the madrone and other forest trees on these soils a similar development and longevity may be looked for in the trees adapted to the soil where its depth is correspondingly great. With this proviso the English walnut in the valleys, the Italian or Japanese chestnut on the hills, would be likely to do well.

Soil, from near Healdsburg, Sonoma County; sent by H. Hebron. "The soil is naturally very deep, perhaps 20 feet, with one or two thin streaks of gravel at considerable depth. The land has been cultivated for forty or fifty years, the last ten or twelve in hops, and has had very little manure applied to it. What fertilizer does it need, if any?"

The soil is somewhat calcareous and clayey, and contains 41 per cent of coarse sand. It is quite poor in phosphates, and doubtless would be much benefited by their use where production has fallen off. The application of nitrates at the proper season would also be beneficial.

Soil, from Pope Valley, Napa County; sent by P. H. Wallace. "On

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this soil (of which there is about an acre) grain, when planted, starts off well, but when an inch or two high a part will die down; the rest will grow, head out, but will have no grain in the head. The land is level, and there are drain ditches on each side of the tract, about 5 feet deep; there is no apparent change in the character of the soil to that depth."

The soil is deep black and very stiff. It is naturally very fertile, and the trouble is due to some local condition, such as lack of proper drainage, etc.

No. 851. Soil, from Livermore Valley, Alameda County; sent by Mr. J. H. Wheeler, Livermore.

"The soil is from the western half of Livermore Valley. A well dug on the place showed it to be 8 feet deep and underlaid by at least 45 feet of drift material, comprising large stones, gravel, and fine earth."

The sample sent is a mouse-gray loam, quite fine and silty, but with scattering small quartzose gravel to 5 mm. size and sand grains of 1 to 2 mm. size. The dry lumps crush readily between the fingers; darken considerably on wetting, and become quite plastic, though not tenacious. It is slightly effervescent with acid. This is understood to represent the properly alluvial soil of the Arroyo del Valle. A full analysis of the soil shows the following constituents:

No. 851. Alluvial Soil of Arroyo del Valle, Livermore, Alameda County.

Coarse materials >0.5mm	5.00
Fine earth	95.00
	100.00

Analysis of Fine Earth.

Insoluble matter	65.28	75.53
Soluble silica	12.25	
Potash (K_2O)		1.09
Soda (Na_2O)		.29
Lime (CaO)		1.27
Magnesia (MgO)		2.48
Br. ox. of manganese (Mn_3O_4)		.03
Peroxide of iron (Fe_2O_3)		5.52
Alumina (Al_2O_3)		6.87
Phosphoric acid (P_2O_5)		.20
Sulphuric acid (SO_3)		.07
Water and organic matter		4.61
Total		99.96
Humus		.42
Ash		.93
Soluble phosphoric acid		.03
Hygroscopic moisture (absorbed at 16° C.)		5.28

This soil shows an excellent composition for high production as well as durability, containing, as it does, large proportions of potash, lime, and phosphoric acid; its humus content is somewhat low for an alluvial soil, and should be increased by green manuring in the future, and nitrogenous fertilizers will probably be the first to be required by it. Its depth of 5 to 7 feet, with little change, seems to render it well adapted to fruit culture, and grapes have been very successful on it. It is underlaid at varying depths by a very gravelly soil or deposit, upon which also vine plantations have been made. While the soil intermingled with this gravel is doubtless very good, the subjoined mechanical analysis shows how very small is the proportion of really active soil; hence, however rich, lasting productiveness is not to be looked for

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on this gravelly land, unless its soil deposit is of considerable depth. This is the case at a number of points, as I have personally verified, in the neighborhood of Pleasanton, where, moreover, the soil portion is quite black with humus, and evidently very rich; as is evinced also by the large size of the oak timber originally growing upon it.

The gravel subsoil contains the following material:

Large stones	60.4 per cent.
Material between 8mm and 1.5mm	14.7 per cent.
Material between 1.5mm and 0.6mm	11.8 per cent.
Fine earth	13.1 per cent.

Soils and subsoils; sent by Lawrence Russell, Saratoga, Santa Clara County.

No. 1. A dark soil, on which walnut trees thirteen years old give a very poor yield. The soil contains 40 per cent of clay and fine earth, and some large fragments of rock. Its subsoil is of a dark yellow color, rather lumpy, but yields readily to water. There is a fair amount of phosphoric acid present in both soil and subsoil. The cause of failure seems to be a very heavy subsoil that is seen in that region. Prunes might do very well, and it is a great deal better for peaches and almonds than the next soil. The use of ammoniated superphosphate, with potash, is suggested.

No. 2. A clayey soil, on which apricots four years of age show only a growth of two years. The soil is lumpy, and has a yellowish adobe subsoil, which does not yield readily to water. In both, the amount of phosphates is extremely small, and this is the evident cause of the trouble. The use of plain superphosphate, giving to each tree about three pounds, deeply worked in, not too close to the tree, should remedy the evil. Almond trees would also require the same fertilizer.

Mountain soils and subsoils, 3 miles east of Alma, Santa Clara County; sent by R. G. Adair. They are from the slopes of Santa Cruz Mountains, at an elevation of from 1,400 to 1,600 feet above sea-level, and the five samples are fair representatives of the soils of the region.

Nos. 1596–7. Dark mountain soil, underlaid at 6 inches by a reddish subsoil; southern exposure and elevation of 1,600 feet; growth, live oaks, manzanita, chamisal, and toyon.

Nos. 1598–9. Dark red soil, underlaid at 8 inches by a lighter subsoil; northern exposure and elevation of 1,500 feet. Growth, thick and close, of madrone, toyon, mountain mahogany, manzanita, chamisal, mountain laurel, yerba buena, etc.

No. 1600. Dark mountain soil, with no apparent change to a depth of 20 inches. It is gravelly in character, especially near and on the surface. It has a northern exposure and an elevation of 1,400 feet above sea-level. Its growth is chiefly laurel, with live oaks and toyon. This soil is peculiar to this locality, occurring in streaks of a mile in length and one tenth wide. Trees grow taller on this slope than on the table-land.

The soils contain an abundance of lime, but the percentages of potash, phosphoric acid, and humus are rather low; and while producing well for a few years will then need fertilizers. Grapes, almonds, and prunes are best adapted to these soils, provided the exposure is suitable. Olives and apples should do finely. The soil and location are suitable for high-class wine grapes, especially clarets. Table grapes will doubtless do well, and Tokays would probably give high color.

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Soil and subsoil; sent by Wm. Etchells, Saratoga, Santa Clara County. Soil varies in depth from 8 to 12 inches, and is a loose, dark loam, plastic with water. The subsoil, to a depth of 30 inches, is a hard, yellowish clay, which does not yield readily to water. Original growth, live and black oak, chamisal, poison oak. Depth to ground water, 20 to 25 feet.

"The French prunes on plum roots that are planted on the land neither grow new wood nor bear much fruit, and that very small in size. They come out in bloom nicely, but the bloom and fruit drop at the same time. The wood is soft and breaks easily, and has a very yellow appearance when broken. What fertilizer is needed?"

An examination shows that these soils are very poor in phosphates, and the account given above corroborates the suggestion that this is the cause of the trouble. The soil is poor in lime, and therefore is in need of an active form of nitrogen, the lack of which is indicated by the unthrifty growth of trees. It is therefore suggested that a nitrated superphosphate be used at the rate of not less than 600 pounds per acre; preferably 1,000 pounds if the trees are large. If the subsoil is a hardpan it must be broken up; and to prevent injury to the trees the best way is to explode a couple of No. 2 giant powder cartridges on each side of the tree, at a distance of 2 to 3 feet away.

Subsoil, from the western foothills of Santa Clara Valley; sent by Dr. P. M. Lusson, San José.

"The overlying soil consists of 30 to 40 inches of a black and reddish gravelly sediment. Trees grow well on it; will they do so for many years?"

The sample is a stiff red adobe, not calcareous, and which does not yield readily to water. There is a very small amount of phosphates present. This is the chamisal land of that valley, and experience has shown it to be a good soil for vines, the roots of which penetrate without difficulty, and make a high quality of wine. It is probably adapted to most fruits, except, perhaps, the pear, and there is no reason to doubt longevity; prunes would before long doubtless require some aid in the way of nitrogenous fertilizers to keep up their size.

Soil; sent by N. C. Briggs, Jr., Hollister. A calcareous, grayish loam, made up of 16 per cent of coarse sand and 84 of fine earth and clay. It contains a fair percentage of phosphoric acid.

No. 1423. Chocolate-colored soil, of Carisa Plain, Sec. 2, T. 11 N., R. 27 W., San Luis Obispo County; sent by F. C. Howard, Painted Rock Post Office.

Carisa Plain is a basin or valley lying to eastward across a low ridge from the upper San Juan Valley, and is bounded on the east by the western slope of the border range of the San Joaquin Valley. It is said to be about 10 miles wide by 60 in length. An analysis of this soil gave the following results:

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No. 1423. Soil of Carisa Plain, San Luis Obispo County.

Coarse materials >0.5mm		9.0
Fine earth		91.0
		100.0

Analysis of Fine Earth.

Insoluble matter	57.33	69.48
Soluble silica	12.15	
Potash (K_2O)		1.22
Soda (Na_2O)		.77
Lime (CaO)		4.46
Magnesia (MgO)		3.12
Br. ox. of manganese (Mn_3O_4)		.01
Peroxide of iron (Fe_2O_3)		7.65
Alumina (Al_2O_3)		10.16
Phosphoric acid (P_2O_5)		.43
Sulphuric acid (SO_3)		.06
Water and organic matter		2.63
Total		99.99
Humus		.39
Ash		.95
Soluble phosphoric acid		.06
Silica		.50
Hygroscopic moisture (absorbed at 15° C.)		8.46

The coarse material rejected from the analysis comprises chiefly rounded sand and gravel of a greenish color, probably diorite; some white quartz and a few particles of a columnar, heavy mineral. The analysis shows the soil to be one of the richest in the State. It has a higher percentage of phosphates and more of them in a soluble condition than any soil thus far observed. In all other respects it is also very good—in potash, lime, humus, and even in retention of moisture. It is said to have ample depth and to be well drained, and if alkali does not interfere, there is no reason why all fruits should not do well, except perhaps almonds, for which it is a little heavy.

Soils and subsoils, six in number, from Alfred Guillon, Hueneme, Ventura County. They comprise a good soil, free from alkali, highly productive; an uncultivated soil with black alkali; two soils—subsoil and under-subsoil—with white alkali, together with white particles which prove to be gypsum.

The complaint is that the white alkali in these latter soils seems to absorb moisture to such an extent as to make the soil cold and damp—conditions which work against summer crops. "The seed, if planted too early, rots in the cold ground, and if planted late, starts well and makes a fine growth until the middle of July, when it begins to shrink and wither for want of moisture. The salts hold their moisture all summer, and in September the ground seems unduly damp. I have had alfalfa seed lie in such ground from April to August unsprouted. The ground could be made into balls that would roll, and it seemed folly to irrigate; yet a night's wetting caused the seed to sprout immediately. There is no hardpan beneath the land, as shown in a number of wells bored to a depth of 150 feet. The surface soil shades off into pure clay, generally of a dark color; and below this clay bed of varying thickness are successive strata of clay and quicksands, the water stratum being a coarse sand, pebbles, or even bowlders. The specimen sent becomes a clay at about 18 feet. The ground water is about 10 feet below the surface in summer, and 4 feet as an average in winter. A 12-foot well will yield water all the year round, but often so saline as to make stock sick. In the lowest spots this soil grows only samphire; generally it grows

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only a chenopodium, called here 'alkali weed.' Under cultivation and surface ditches to prevent puddles, with summer fallowing, it grows a few diminutive annual malva and indigo weeds. When planted in barley the seed is very slow in sprouting, but once up it will do well until 4 or 5 inches high, when, unless it gets a good wetting, it begins to wither. If it gets a good rain about once every six or seven weeks it will mature with a light, rather shrunken grain and very dark and thin straw. In a summer crop this ground warms up very slowly, and the seed will not sprout within two weeks of its sprouting on good soils; once up it will grow for a few weeks and then shrink and turn yellow; irrigation will revive it."

An examination shows that the "good soil" has no appreciable amount of alkali, but a large amount of phosphoric acid, thus making it indeed a good one. The uncultivated soil with its black alkali requires a treatment with gypsum before cultivation. The white alkali soil gives on leaching 1.1 per cent of alkali salts, and 0.3 per cent of gypsum. The hygroscopic moisture in it after exposure to an atmosphere saturated with moisture at about 60°, is only 7.6 per cent, or about 5 per cent in its normal state; it therefore is not very moist, and the feeling of moisture is due probably to the salts it contains. The white alkali salts are excessive in quantity, even though not injurious in quality; they act injuriously by interfering with the plant's root absorption, if not otherwise, and they alter the whole capillary character of the soil. If the sample is a fair one of the whole of the summer-fallow slice, and not merely on the surface, it will be hard to reclaim the land without under-drainage—that is, leaching-out. Its content of phosphoric acid is only fair; not nearly as high as that of the good soil. There can be no question that this is one of the cases in which the only chance of successful cultivation outside of under-drainage is in very deep and thorough tillage, given in the spring and maintained throughout the growing season, keeping the surface so loose that evaporation, and therefore the accumulation of the salts at any one point or level, will be reduced to a minimum. It is very evident that at present there is enough phosphoric acid for any crop; of potash certainly an abundance, and so of lime; humus shows itself in the color of the soil. It is the excess of salt that hurts the crop. The fact that harrowing did so much good confirms that conclusion and points the way for the future; when the soil is got into good tilth there will be less trouble every year. The expediency of harrowing grain in general depends a good deal on the time of sowing. There is little doubt about its being good for winter grain; but as the season advances the setback given for the moment may become serious if the rains should fall short and a norther come while the surface is loose and the roots partially exposed. The fact that the white alkali land requires more water than the good soil, is referable to the injury done by the concentration of the salts near the surface and around the feeding roots; when diluted by irrigation this handicap is removed. But speaking of the effects of alkali in dry lands, it is a curious fact in point that in the northern part of the Great Bend country of Washington, it is only on the alkali soil that crops succeed every year without irrigation; and when you pass over the region after a dewy night you find the whole ground streaked with black moisture, as though it had rained in streaks. This also happens in the Wenass Valley, Washington. (E. W. H.)

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D. SOUTH CALIFORNIA.

Red loam soil and subsoil, from Azusa, Los Angeles County; sent by M. G. Eshman.

"The soil averages about 20 inches in depth; the subsoil is much more hard and compact, especially when exposed to the sun, although it seems to readily yield to water. The land is well drained, having a grade of 90 feet per mile in one direction and 40 feet in the other, and is devoted to orange culture, the trees having made a magnificent growth. The roots of the trees seem to be taking hold of the hardpan subsoil very well."

More than one half of the soil is of clay and fine earth, and gives to it a stiff character. The subsoil is very similar to the soil; its hard lumps yield slowly to water. The soil is evidently a part of the red bench that extends around the valley from Redlands down, and there can be no question of its quality for orange culture for the time being, whatever may have to be done after the trees get into bearing, when the more minute differences have to be considered. The soil is rich in phosphates. All that region is rich in potash, both in soils and irrigation waters; the whole of it is poor in humus, and will have to make that up whenever the crops come in somewhat heavily, by using nitrogenous fertilizers. It is more in regard to the mechanical nature of the soil that questions come in at present, especially in respect to the underlying hardpan. The fact that it softens readily in water indicates that irrigation water will do the same thing for it, and will, under cultivation, gradually cause it to become more pervious. The fact, also, that it is very red, alone proves that it is capable of drainage and will not cause water to stagnate—the worst thing that could happen to an orange tree.

No. 1607. Reddish sandy soil, from 3½ miles southwest of Lancaster, in Antelope Valley, Los Angeles County, 2,350 feet above sea-level; sent by E. C. Coleman.

"The growth is chiefly of yucca palms, very thrifty and of large size; many of them are from 4 to 6 feet in circumference, and have very large and dense tops; sagebrush, and a scattering growth of bunch grass and cactus. The soil was taken from 8 to 10 inches deep. At 3 or 4 feet there is a clayey sand of a reddish, porous nature. It is 3½ miles from the mountains, and is smooth, sloping gently to the north. In the spring months flowers of many varieties spring up in great profusion."

No. 1607. Soil of Antelope Valley, Los Angeles County.

Coarse materials > 0.5 mm	30.00
Fine earth	70.00
	100.00

Analysis of Fine Earth.

Insoluble matter	80.48	87.25
Soluble silica	6.77	
Potash (K_2O)		.49
Soda (Na_2O)		.15
Lime (CaO)		.97
Magnesia (MgO)		.93
Br. ox. of manganese (Mn_3O_4)		.05
Peroxide of iron (Fe_2O_3)		4.23
Alumina (Al_2O_3)		4.19
Phosphoric acid (P_2O_5)		.07
Sulphuric acid (SO_3)		.04
Carbonic acid (CO_2)		.....
Water and organic matter		1.40
Total		99.77

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Humus	.15
Ash	.19
Soluble phosphoric acid	.01
Silica	.13
Hygroscopic moisture (absorbed at 15° C.)	1.22

The above soil is rich in potash and lime, but not in phosphoric acid. Of the latter it has the same amount as the mesa subsoil of the Temescal Valley, on the south side of the San Bernardino Valley, and of the brownish loam soil of the Windsor tract of Arlington Heights. Altogether, it is typical of the South California soils in high potash, lime, and magnesia, and medium phosphoric acid, although at so high an elevation.

Soil, from 5 miles southwest of Lancaster, Antelope Valley, Los Angeles County; sent by R. P. Sibley, Los Angeles.

"This soil is in the artesian belt, the water being at a depth of 10 to 20 feet from the surface. The vegetation comprises large yucca trees, some with trunks 1 to 2 feet in diameter, and 15 to 20 feet high; thick sagebrush. This sandy loam soil seems to be very deep; in an adjoining section there is a few inches of hardpan beneath the soil."

An examination shows the soil to contain much mica, plagioclase, garnet, hornblende. Twenty per cent of the soil is of clay and fine earth, and 80 per cent of sand. The soil should be very deep to be durable; the fine earth is extremely rich in phosphoric acid, and as the material is largely decomposed granite, it may be presumed to be rich also in potash. The soil should be of very general adaptability; peaches and olives will certainly do well; also almonds, if the climate permits; prunes and apricots should be of specially fine quality, though there may be a question of adequate size. Should there be any trouble in the latter respect, it would be remedied by the use of some nitrogenized fertilizer, since that is the point in which the soil is weak.

Soils and subsoils, from E. J. Durant, Pasadena, Los Angeles County.

Nos. 1486–7–8. Grayish, sandy soils and subsoils of Fairmount Valley, situated about 2 miles from the high hills on the northern slope of Sierra Madre Mountains, and lying about 50 feet below the general surface of the country, and about 2,500 feet above sea-level. The valley opens out into Antelope Valley, and is covered with alfilerilla; no brush. The soil is from 20 to 36 inches deep.

Nos. 1489–90. Soil and subsoil of Antelope Valley, 2 miles north of Lancaster; "represents thousands of acres, 50 to 100 feet above the bottom of the valley on the south side. It is covered with the so-called sagebrush. Are these lands adapted to grains or fruits, and of what kinds?"

The soils are fawn-colored, sandy loams, with much coarse sand; barely plastic on wetting. They are granitic in character, and hence rich in potash, and fairly so in phosphates. Under irrigation they will doubtless be very productive for a number of years; but they will not bear such crops as require much nitrogen (such as wheat, oranges, and prunes) for a long period without some help. This help will consist in green-manuring with alfalfa, clover, or vetches, or in supplying nitrogen from commercial fertilizers, etc. It will last a long time for grapes, apples, pears, and most other fruits, but peaches, almonds, and apricots are likely to do better than apples, pears, or prunes. Olives should do finely. For citrus fruits the soil is a shade too open, but with plenty of water at command the soil should not hinder if the *climate* suits.

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Soils, from Etiwanda, San Bernardino County, 2 miles from the foot of the mountains; sent by Dr. O. S. Winstanley, Los Angeles.

1. A loose, sandy soil, made up of 5 per cent of clay and fine earth, and 95 per cent of sand, gravel, and some large fragments of rock. There is no alkali present, while the percentage of phosphoric acid is ve[redacted]

Soil, subsoil, and under-subsoil, of Santa Ana Valley, 2½ miles north of Santa Ana, Orange County; sent by John McCue.

"The soil was taken 12 inches deep, the subsoil from 12 to 24 inches, and the under-clay 24 to 36 inches from the surface. There was only a slight change in color downwards. The land has been under cultivation and irrigation for about sixteen years. The soil dries out quickly, and can be cultivated twenty-four hours after irrigation. Water rises in wells to about 20 feet of the surface. The land is underlaid below the water line by sand and gravel. This valley is a broad plain about 15 miles west of the Santa Ana Mountains, and is said to have been originally covered with a growth of cactus and willows. It is at present devoted to the culture of citrus and deciduous fruits and walnuts, and with an abundance of water produces good corn, barley, alfalfa, peanuts, and sweet potatoes. What does the land need in the way of fertilizers?"

The soil and subsoil are both dark sandy loams, free from alkali, and with a fair percentage of phosphoric acid; the under-subsoil is more sandy and gravelly. In composition the soil is so well balanced that it

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is not certain which ingredient is liable to become deficient first; but, from the nature of the soil, it is probable that in phosphates first, and afterwards nitrogen, will lie the most profitable mode of fertilization. As a part of the ancient delta of the Santa Ana River it of course must vary widely in respect to the amount of sand, and particularly in the kind of subsoil; just as in the Kaweah delta in the San Joaquin Valley we have apparently a uniform surface soil over considerable areas, but when a droughty time comes the drying out of the grain outlines exactly the old channels underlaid by coarse sand, which fails to supply moisture from below. Of course the depth of true soil above this sand or gravel streak will make a great difference in the adaptation or durability, and the crops or trees on such streaks will have to be fed with fertilizers much sooner than those having a more substantial subsoil. But since all is derived more or less from the alluvium of the Santa Ana River, there is probably little variation in intrinsic quality, apart from sand. Commercially speaking, an ammoniated superphosphate is the kind of fertilizer indicated by the examination. According to the analysis of the river water it carries enough potash for all ordinary purposes. Almonds, peaches, and citrus fruits would seem to be indicated as the most suitable to this soil. (E. W. H.)

Soils and subsoils, from San Diego; sent by Wm. A. Winder.

"On this land were planted, four years ago, apricot, prune, pear, and apple trees. The apricot trees made good growth, but instead of growing tall, spread out horizontally near the ground and did not yield well; some of the trees have died, and this season several that promised well in the early spring are dying. The plum and prune trees have made but little growth, and have not yet fruited. The prune trees have in several instances died out and been replaced by others, which also have died. Several pear trees have died, and others seem to be dying. The apple trees are doing fairly well. The land appears to be rich, and was originally covered with a heavy growth of brush. The land is sheltered from the sea wind, being several miles from the ocean; there is abundant moisture in the soil, and cultivation has been carefully attended to, no weeds having been allowed to grow. The soil is a dark loam."

The condition of the trees points to a deficiency in phosphates in the soils, and the chemical examination of the soil corroborates this inference, for the amount of phosphoric acid is very small. A simple superphosphate, well worked in, will be likely to produce a good effect on the trees recently planted. If irrigation can be done, two or three pounds of the fertilizer per tree put in a circular ditch, not less than 2 feet away from the tree, and allowed to soak in, would be a good test.

MECHANICAL ANALYSES OF SOILS.

The mechanical analysis of the soils of the State has been carried on as fast as circumstances would permit, and the results are presented below.

The determination of the percentage of the several constituents of clay, silts, sands, and grits that comprise a soil is a matter of much importance, for upon these depend to a large degree its physical properties. The separation of these has been made with a soil elutriator devised by Professor Hilgard a number of years ago, and based upon

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the buoyant power of different upward currents of water, each moving under a constant and uniform velocity. The tendency of the fine particles to coalesce and fall, and which has ever been one of the chief causes of trouble in other methods of analysis, is in this instrument avoided by the use of a churn arrangement, which breaks up this union of particles. This property of flocculating belongs to all particles of less than one ninth of a millimeter in diameter, or to those which are borne up in a current of water moving at the rate of 8 mm. per second.*

The advantages of this instrument above all others are its easy manipulation; exact separation of sediments; an almost indefinite number of subdivisions; and it allows the operator to carry on other work while keeping an ear open to the regularity of movements in the motor and the bubbling of air in the water reservoir. The full description of the elutriator and its work is given in an Appendix of this report.

In the divisions of sediment given in the analyses below, Professor Hilgard has noted that, so far as the porosity of the soil, on the one hand, and its compactness or resistance to tillage, on the other, are concerned, the silt sediment having a buoyancy of 0.5 mm., or one thirty-sixth of a millimeter in diameter, seems to be neutral.† The sediments were therefore grouped together by him in two chief classes on either side of this neutral silt:

1. The coarse portion, which increases the lightness and porosity of the soil, sensibly in proportion to its percentage.

2. The fine portion, which, while modifying the plastic properties of the clay, yet renders the soil heavier in tillage than would be the case if it were absent and the clay adherent to the coarse particles alone.

Soils consisting mainly of very fine silicious silt, with only a small percentage of clay, are among the heaviest, working "like putty," clogging the plow when in the least degree too wet, and in drying, caking into cakes of "hardpan."

No. 1281. Sandy soil, from South California Experiment Station, near Chino Ranch, San Bernardino County. A reddish-gray or fawn-colored, sandy loam; the dry lumps fall to pieces readily and show much sand, some coarse, up to one eighth of an inch diameter. The sand grains are mostly granular, colorless quartz, with much feldspar, black grains of augite, as well as of hornblende and some garnet occasionally imbedded in fragments of chloride schist. The soil when wetted darkens slightly and becomes slightly plastic but not adhesive.

*The instrument is now made under the supervision of Mr. Sladky, of the College of Mechanics, University of California, and has been adopted by several of the Experiment Stations of other States.

† Proc. Am. Assoc. Adv. of Science, 1873, page 76.

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Mechanical Analysis.

Grits	10.00
Fine earth	90.00
	100.00

Mechanical Analysis of Fine Earth.

Clay			7.60
Finest silt	<0.25	mm. hydraulic value	15.52
Fine silt	0.25	mm.	3.01
Medium silt	0.5	mm.	5.49
Coarse silt	1.0	mm.	3.92
Coarsest silt	2.0	mm.	6.40
Dust	4.0	mm.	7.92
Finest sand	8.0	mm.	11.87
Fine sand	16.0	mm.	16.36
Medium sand	32.0	mm.	14.65
Coarse sand	64.0	mm.	5.10
			97.83

Water-holding percentage	33.40
Hygroscopic moisture	1.98

The soil contains a fair percentage of clay and of finest silt, which gives to it a percentage of compactness of 26 against 66 of porosity. The water-holding power of the fine earth is 33.4 per cent, which is reduced to 32 by the admixture of the 10 per cent of coarse sand of more than 0.5 mm. diameter.

No. 1115. Granite soil, from the Foothills Experiment Station, near Jackson, Amador County. It is a gray or fawn-colored, sandy loam, full of granite debris; dry lumps very readily crush between the fingers. On wetting, the color darkens, showing the presence of humus, but on kneading only a slight adhesiveness is developed. The chemical analysis of the soil is given in the report for 1888–89.

Mechanical Analysis.

Coarse materials above 0.5 mm. diameter	40.00
Fine earth	60.00
	100.00

Mechanical Analysis of Fine Earth.

Clay			11.86
Finest silt	<0.25	mm. hydraulic value	16.82
Fine silt	0.25	mm.	4.10
Medium silt	0.5	mm.	3.25
Coarse silt	1.0	mm.	3.90
Coarsest silt	2.0	mm.	5.88
Dust	4.0	mm.	6.26
Finest sand	8.0	mm.	10.29
Fine sand	16.0	mm.	13.66
Medium sand	32.0	mm.	15.48
Coarse sand	64.0	mm.	6.59
			98.09

Water-holding percentage of fine earth	42.50
Hygroscopic moisture percentage	5.93

The soil contains a large percentage of very coarse sand and gravel. But in the fine earth alone there is quite an amount of clay and finest silts, which give a tenacity percentage of 32.78 against 62.06 of porosity. The greater part of the latter is of medium sand of less than 5 mm. diameter. The fine earth alone of the soil can hold 42.5 per cent of water, or 4 per cent more than No. 1167, which has 6 per cent more of clay and finest silt. In an atmosphere saturated with moisture the fine earth absorbs 5.93 per cent of moisture.

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No. 1595. Sandy soil, 8 miles from Castroville, Monterey County.

Mechanical Analysis.

Clay			2.60
Finest silt	<0.25	mm. hydraulic value	5.46
Fine silt	0.25	mm.	.84
Medium silt	0.5	mm.	.28
Coarse silt	1.0	mm.	.74
Coarsest silt	2.0	mm.	.86
Dust	4.0	mm.	.95
Finest sand	8.0	mm.	3.10
Fine sand	16.0	mm.	5.38
Medium sand	32.0	mm.	33.81
Coarse sand	64.0	mm.	43.16
			97.17

This is a very sandy soil, 88 per cent of its weight being of those silts and sands which give to it looseness and porosity. It will be noticed that the coarse sands are in largest proportion.

No. 1167. Black land soil, from Mussel Slough region, west of Tulare City, Tulare County. It is blackish gray soil, darkening a good deal on wetting. The dry lumps crush with some difficulty between the fingers, and on wetting become fairly plastic, so as not to be tillable when wet.

Mechanical Analysis.

Grits	10.60
Fine earth	89.40
	100.00

Mechanical Analysis of Fine Earth.

Clay			14.65
Finest silt	<0.25	mm. hydraulic value	18.67
Fine silt	0.25	mm.	5.54
Medium silt	0.5	mm.	5.48
Coarse silt	1.0	mm.	3.48
Coarsest silt	2.0	mm.	6.99
Dust	4.0	mm.	5.73
Finest sand	8.0	mm.	5.48
Fine sand	16.0	mm.	6.96
Medium sand	32.0	mm.	14.76
Coarse sand	64.0	mm.	9.77
			97.49

Water-holding percentage of fine earth	38.30
Hygroscopic moisture	5.58

This soil is very rich in clay, which with the finest silts give to it a fair percentage of plasticity. The water-holding power is also very fair, as well as its power of absorbing hyroscopic moisture from a moist atmosphere. In this soil, the percentages representing compactness and water capacity are nearly identical.

No. 1113. Slate soil, from the Foothills Experiment Station, Jackson, Amador County. An orange-red loam, the lumps of which are easily crushed between the fingers when dry, and show considerable coarse sand; when wetted becomes only moderately adhesive, while its color darkens materially. Slate fragments are intermingled more or less all through, much of the sand being comminuted slate. The chemical analysis of the soil is given in the report for 1888–89.

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Mechanical Analysis.

Weight of gravel over 1.2 mm. diameter	13.95
Weight of gravel between 1.2 and 1 mm.	.20
Weight of gravel between 1 and 0.6 mm.	1.85
Fine earth	84.00
	100.00

Mechanical Analysis of Fine Earth.

Clay		16.43
Finest silt	<0.25 mm. hydraulic value	30.26
Fine silt	0.25 mm.	4.64
Medium silt	0.5 mm.	9.96
Coarse silt	1.0 mm.	7.68
Coarsest silt	2.0 mm.	8.21
Dust	4.0 mm.	5.91
Finest sand	8.0 mm.	4.03
Fine sand	16.0 mm.	5.04
Medium sand	32.0 mm.	2.89
Coarse sand	64.0 mm.	2.17
		97.22

Water-holding percentage of soil	42.50
Water-holding percentage of fine earth	47.50
Hygroscopic moisture of fine earth	5.74

It is at first surprising that, with so large a percentage of clay and finest silt, the soil is not more adhesive when wetted. We find greater plasticity in some soils having less of these three sediments than is shown here. The cause evidently lies not so much in the amount of the sediment as in the nature of that sediment which is derived from the decay and disintegration of ferruginous slate, whose composition, as shown by an analysis of the soil, is largely silicate of alumina, magnesia, and potash, with nearly 12 per cent iron. There is something lacking to produce plasticity, and that may be free hydrated silica. Its water-holding power is 42.5 per cent, but its hygroscopic moisture is not as great as that of the granitic soil which has far less free material.

No. 1197. Soil, from the bottom land of Gila River, near Yuma. It is of a pale, fawn color when dry; fine-textured, silty, with no coarse sand or gravel of any kind. It, and the subsoil, which is very similar to it, lie loosely, and can be compressed considerably with little exertion. The natural vegetation is mainly mesquite and "Colorado hemp." The chemical analysis is given in the report for 1890.

Mechanical Analysis.

Clay		3.21
Finest silt	<0.25 mm. hydraulic value	3.32
Fine silt	0.25 mm.	2.21
Medium silt	0.5 mm.	2.04
Coarse silt	1.0 mm.	3.21
Coarsest silt	2.0 mm.	10.17
Dust	4.0 mm.	13.01
Finest sand	8.0 mm.	33.97
Fine sand	16.0 mm.	22.00
Medium sand	32.0 mm.	2.79
Coarse sand	64.0 mm.	.28
		94.22

Water-holding percentage	32.00
Hygroscopic moisture percentage	3.48

This is a very porous, sandy soil, largely made up of sand of a buoyant power of from 4 mm. to 16 mm., inclusive. The percentage of clay and fine silts, which give tenacity or plasticity with water, is very small. The water-holding power is surprisingly large for so sandy a soil, and

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its cause is not at present apparent. It is even larger than in several soils having three times the percentage of compactness. Its power of absorbing hygroscopic moisture in a moist atmosphere is also very fair.

No. 233. Sandy soil, from Morrano, 6 miles south of Lathrop, San Joaquin County. Natural vegetation, clover, alfilerilla, some salt and bunch grass.

Mechanical Analysis.

Clay			2.82
Finest silt	<0.25	mm. hydraulic value	2.79
Fine silt	0.25	mm.	.24
Medium silt	0.5	mm.	.76
Coarse silt	1.0	mm.	.50
Coarsest silt	2.0	mm.	2.23
Dust	4.0	mm.	5.00
Finest sand	8.0	mm.	10.13
Fine sand	16.0	mm.	15.50
Medium sand	32.0	mm.	23.92
Coarse sand	64.0	mm.	34.68
			98.57

This is also a very porous, sandy soil, more than 91 per cent of its ingredients being of coarse silt and sand, of which there is a regular increase of percentage from fine to coarse. There is scarcely enough clay and fine silt to bind the particles together, the ratio between these ingredients affecting its compactness and porosity, respectively, being as 5.85 to 91.86.

No. 1147. Soil of the Southern Coast Range Experiment Station tract, near Paso Robles, San Luis Obispo County. It is of a reddish gray or fawn color, which deepens considerably on wetting by bringing out the color of the humus present; but it can hardly be said to assume any plasticity, and could evidently be safely plowed almost at all times. The chemical analysis is given in the report for 1888–89.

Mechanical Analysis.

Weight of gravel over 1.2 mm. diameter	18.50
Weight of gravel between 1.2 and 1 mm.	14.80
Weight of gravel between 1 and 0.6 mm.	11.75
Fine earth	54.95
	100.00

Mechanical Analysis of Fine Earth.

Clay			7.40
Finest silt	<0.25	mm. hydraulic value	13.39
Fine silt	0.25	mm.	4.38
Medium silt	0.5	mm.	6.05
Coarse silt	1.0	mm.	8.55
Coarsest silt	2.0	mm.	8.35
Dust	4.0	mm.	6.75
Finest sand	8.0	mm.	5.60
Fine sand	16.0	mm.	8.88
Medium sand	32.0	mm.	15.17
Coarse sand	64.0	mm.	14.24
			98.73

Water-holding percentage	28.50
Hygroscopic moisture percentage	1.84

The soil is largely made up of gravel, only a little more than one half being of fine earth. Even the fine earth contains more than half its weight of sand, the larger part of the remainder being silt, which serves to bind the particles together, giving tenacity and increasing the capillary power of the soil to draw on the ground water. The fine earth will hold but 28.5 per cent of water.

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No. 1159. Sandy soil, from the Experiment Station tract near Tulare City. It is of a buff tint, quite sandy, not assuming any plasticity on wetting and kneading, and capable of tillage at all times; originally timbered with scattering but large white oaks. Samples were taken to a depth of 12 inches. The chemical analysis of this soil is given in the Report of Experiment Stations for 1888–89. The following shows the mechanical ingredients that form the soil:

Mechanical Analysis.

Grits		1.96
Fine earth		98.04
		100.00

Mechanical Analysis of Fine Earth.

Clay		5.71
Finest silt	<0.25 mm. hydraulic value	7.58
Fine silt	0.25 mm.	3.36
Medium silt	0.5 mm.	4.10
Coarse silt	1.0 mm.	5.48
Coarsest silt	2.0 mm.	7.05
Dust	4.0 mm.	9.06
Finest sand	8.0 mm.	16.71
Fine sand	16.0 mm.	23.83
Medium sand	32.0 mm.	13.37
Coarse sand	64.0 mm.	.89
		97.13
Water-holding percentage		26.40
Hygroscopic moisture percentage		2.71

About four fifths of the soil is comprised in the sediment above 1 mm. hydraulic value, or of that which gives looseness to its texture. There is enough of the fine sediments present to make it loamy in character.

No. 863. Red soil, from the neighborhood of Grass Valley, Nevada County. "Overlies the ancient gravel deposits, which are covered by it, sometimes with a light-colored, clayey subsoil, to the depth of 6 to 10 feet, when a "cement" formation is struck. It occurs chiefly to northward and eastward from Grass Valley; in fact, it covers all the hills under which the auriferous gravel beds are found." The soil is a light loam of a deep red tint. Dry lumps crush easily between the fingers. When wetted the color darkens considerably, and the soil becomes only slightly plastic, showing but a small amount of clay. The chemical analysis of this soil is given in the report for 1888–89.

Mechanical Analysis.

Clay		24.78
Finest silt	<0.25 mm. hydraulic value	21.99
Fine silt	0.25 mm.	10.31
Medium silt	0.5 mm.	2.35
Coarse silt	1.0 mm.	5.81
Coarsest silt	2.0 mm.	5.77
Dust	4.0 mm.	7.48
Finest sand	8.0 mm.	10.65
Fine sand	16.0 mm.	4.44
Medium sand	32.0 mm.	2.86
Coarse sand	64.0 mm.	.75
		97.21
Water-holding percentage		61.35
Hygroscopic moisture percentage		14.20

The soil contains 36.38 per cent of ferric hydrate, the larger part of which came down with the clay and finest silt, and gave to them their

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high percentage. The true clay would thus appear to be in small amount, and the lack of greater plasticity thus accounted for. To the large amount of iron is also due the friable character of the soil when dry. It will be seen that the water capacity and the hygroscopic moisture are both very far greater than in any other soil, even than No. 1113, which closely resembles it in compactness and porosity. This points to the ferric hydrate as an important factor in giving to soils these properties.

DETERMINATION OF ORGANIC NITROGEN IN SOILS.

By M. E. Jaffa.

It is with a view of ascertaining whether there is any definite relation between the organic nitrogen in the soils and the humus, the latter having been already determined* in all of the soils analyzed in this State, that this investigation is now being carried on. This has been rendered necessary by the numerous inquiries from the many farmers, orchardists, and vineyardists who every year see more clearly the commercial advantage of the addition of fertilizers, and also the necessity of returning, in some measure, to the soil, the ingredients of plant food withdrawn therefrom.

Nitrogenous fertilizers being very expensive, it is, of course, the aim of the farmer to use a minimum amount compatible with success, and this is almost impossible, unless the quantity taken out by the crop in question is known, and also the percentage of nitrogen in the soil, which is the main source from which the tree or vine can draw.

The only gauge which we at present have of the organic nitrogen is the humus, which contains all of the nitrogenous compounds of the soil, but they are of too complex a structure to allow of the calculation of the nitrogen from them.

The method of analysis pursued is as follows: The soil is first treated as in the case of humus determination, that is, 5 or 10 grains are leached, in the cold, with dilute chlorhydric acid (0.5 to 1 per cent) until all the lime is extracted. It is then completely washed, and in place of using ammonia, a 5 per cent solution of potassic hydrate is added to the washed soil on the filter. This treatment with potassic hydrate is continued until the solution, upon passing through the filter, is colorless.

This extract, or an aliquot thereof, is acidified with pure sulphuric acid and the nitrogen determined by the Kjeldahl method.

In the table below are given the results so far obtained. The complete analyses of the soils are reprinted from previous reports for the purpose of showing the nature of the soils examined.

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* By the Grandeau process of extraction.

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	No. 37. Valley Soil, Pescadero, San Mateo Co. 12 inches.	No. 702. Chaparral Soil, Saratoga, Santa Clara Co. 12 inches.	No. 863. Grass Valley, Nevada Co.	No. 1536. Brown Loam Soil, Windsor Tract, Arlington Heights, San Bernardino Co.
Analysis of Fine Earth.				
Insoluble matter	78.08	57.45	26.96	63.67
Soluble silica	3.24	5.11	10.96	13.70
Potash (K_2O)	.54	.86	.15	.73
Soda (Na_2O)	.23	.26	.21	.36
Lime (CaO)	.93	1.99	.33	1.58
Magnesia (MgO)	.82	2.43	.30	1.85
Br. ox. of manganese (Mn_3O_4)	.04	.10	.07	.03
Peroxide of iron (Fe_2O_3)	4.93	10.02	8.25	10.02
Alumina (Al_2O_3)	4.82	9.52	36.38	5.06
Phosphoric acid (P_2O_5)	.08	.14	.09	.07
Sulphuric acid (SO_3)	.03	.06	.07	.01
Carbonic acid (CO_2)				
Water and organic matter	6.76	11.92	16.48	2.74
Totals	100.50	99.86	100.23	99.82
Humus	2.28	3.10	2.89	.20
Ash	.73	.88	.76	.35
Soluble phosphoric acid	.05		.05	.04
Silica	.48			.28
Organic nitrogen	.10	.125	.400	.036
Hygroscopic moisture (absorbed at 15° C.)	7.39	12.09	14.20	4.71

An inspection of the table shows that soil No. 1536, with 0.20 per cent humus (the lowest, of the soils analyzed), has 0.036 nitrogen, or 18 per cent of the humus, while soil No. 863, containing 2.89 of humus, has 0.40 per cent nitrogen, which is about 14 per cent of the humus; not a very great variation, as regards the nitrogen contents of the humus, from the above.

The same general relation is shown between soils Nos. 37 and 702, the nitrogen being something less than 5 per cent of the humus in each case.

But there is no agreement, in this respect, between No. 37 and No. 1536, or No. 863.

The data thus far ascertained is not sufficient to warrant us drawing any conclusions, but the completion of the examinations now under way, and soon to be published, may tend to elucidate this interesting subject to a very great extent.

For the present we can only state the figures without making any discussion thereof.

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II. ANALYSES OF WATERS.

A. STREAM AND LAKE WATERS.

Water, from North Battle Creek, Shasta County, 14 miles east from the Sacramento River, at 1,500 to 1,700 feet altitude; sent by Messrs. Woodward Bros. It is used for irrigation.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	6.42	1.10
Soluble in water after evaporation	1.14	.20
Insoluble in water after evaporation	4.26	.73
Organic matter and chemically combined water	1.02	.18
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.31	.05
Sodium chloride (common salt)	.21	.04
Sodium carbonate (sal soda)	.62	.11
The insoluble part consists of—		
Calcium and magnesium carbonates	2.33	.40
Calcium sulphate (gypsum)		
Silica	1.93	.33

The water is remarkably pure in character and is well adapted for not only irrigation, but for domestic uses. If found to be a little hard from the presence of lime, it can be softened by boiling, or by the use of sal soda.

Water, from Little Klamath Lake, Siskiyou County; sent by J. D. Carr, Esq., of Salinas.

	Grains per Gallon.
Total residue by evaporation	54.3
Soluble in water after evaporation	29.2
Insoluble in water after evaporation	7.6
Organic matter and chemically combined water	17.5
The soluble part consists of—	
Sodium carbonate (sal soda)	27.2
Sodium chloride (common salt)	2.0
Sodium and potassium sulphates	traces only.

The insoluble part consists mostly of calcium and magnesium carbonates, with traces of calcium sulphate (gypsum), and a small amount of silica.

The presence of so much of the carbonates of soda, lime, and magnesia makes the water of the lake totally unfit for use. For irrigation it contains too much carbonate of soda, which would give rise to "black alkali."

Water, from the supply of Santa Rosa, furnished by the Waterworks Company through pipes from a reservoir; sent by Thos. L. Thompson, editor Santa Rosa "Democrat." The sample is clear, tasteless, colorless, and with a very slightly alkaline reaction. Its composition is as follows:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	14.31	2.45
Soluble in water after evaporation	3.50	.60
Insoluble in water after evaporation	9.52	1.63
Organic matter and chemically combined water	1.29	.22
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.58	.27
Sodium chloride (common salt)	.68	.12
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	4.91	.84
Calcium sulphate (gypsum)		
Silica	4.61	.79

The analysis proves this water to be as good as any need be for general use, and rather remarkable for the small proportion of soluble salts it contains. This also shows it to be free for sewage contamination.

Water, from Panoche Creek, near the western edge of San Joaquin Plains; sent by W. K. Brown, of Hollister. The sample was clear and tasteless. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	144.56	24.75
Soluble in water after evaporation	87.20	14.93
Insoluble in water after evaporation	39.54	6.77
Organic matter and chemically combined water	17.82	3.05
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	42.03	7.20
Magnesium sulphate	26.46	4.53
Sodium chloride (common salt)	15.00	2.56
Sodium carbonate (sal soda)	3.71	.64
The insoluble part consists of—		
Calcium and magnesium carbonates	4.79	.82
Calcium sulphate (gypsum)	32.71	5.60
Silica	2.04	.35

The water is altogether too strongly mineral for either domestic or irrigation use. It is a saline purgative; land irrigated with it would soon be charged with "alkali" so as to render it unproductive. It might be used on very sandy and well-drained soils, for small cultures that are constantly kept well worked, and even then the land would have to be leached out from time to time.

Water, from the Del Rio Rey fruit farm, Clifton, Fresno County; sent by D. T. Fowler. "This is bottom water, taken from a pond that arose on the Del Rio Rey last year; does it contain such a percentage of alkali as to injure it for irrigation purposes? There are many such ponds arising through the irrigated sections of the county, and could be used if desirable."

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	13.55	2.32
Soluble in water after evaporation	6.07	1.04
Insoluble in water after evaporation	5.09	.87
Organic matter and chemically combined water	2.39	.41
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	Trace.	
Sodium chloride (common salt)	Trace.	
Sodium carbonate (sal soda)	6.07	1.04
The insoluble part consists of—		
Calcium and magnesium carbonates	4.85	.83
Calcium sulphate (gypsum)		
Silica	.24	.04

The total amount of mineral matter is quite within the limits of what is found in good irrigation waters. The only objection is that what little there is consists of very pure "black alkali," or carbonate of soda. There will not be enough of it for some years to amount to anything, and it may never do so if irrigation is so managed as not to allow the residue to accumulate in the soil—that is, if once or twice a year the land is so persistently flooded that whatever there is in the soil of soluble salts will pass through into the country drainage. Then, too, there is the gypsum remedy, which alone will keep the alkali harmless for many years, perhaps (under the circumstances) forever.

Waters, from the water supply of Santa Barbara; sent by Dr. F. M. Casal, Health Officer. "Our principal supply is derived (1) from Mission Creek, a small mountain stream in Mission Cañon; (2) from several artesian wells, varying in depth from 85 to 215 feet, in the bottom of or near to De la Guerra caisson. The latter is about 7 feet above sea-level, about half a mile from the beach, and in the margin of a marsh adjacent to a small estuary of the sea; (3) from a hillside artesian well 140 feet deep and about 150 feet above sea-level.

"From the caisson the water is pumped and forced through pipes to a maximum elevation of about 200 feet. The pumping agitation of the water in the caisson, the bottom of which is not entirely covered with an impervious pavement, and the velocity of the influent artesian streams, which for uncertain but considerable depths are not confined to their respective tubings, render the water decidedly turbid with the detritus, principally from strata near the surface that one finds in the bed of a marsh. After standing some hours this turbid water becomes clear and a yellowish-brown sediment is formed on the bottom and lower part of the sides of the container. This sediment is very adhesive and is removed with difficulty, even from glass, and is generally described as 'slimy.' This De la Guerra caisson is our principal source of supply in dry seasons, and a sanitary examination of its water is especially desired by our citizens."

The samples received were all clear, with no taste or odor. None of the sediment mentioned above appeared in the waters. (See report on the artesian water, elsewhere.)

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	Mission Creek.		De la Guerra Caisson.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	31.54	5.40	32.42	5.55
Soluble in water after evaporation	10.69	1.83	10.52	1.80
Insoluble in water after evaporation	17.01	2.91	17.23	2.95
Organic matter and chemically combined water	3.85	.66	4.67	.80
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	7.06	1.21	5.31	.91
Sodium chloride (common salt)	1.77	.30	2.73	.46
Sodium carbonate (sal soda)	1.86	.32	2.48	.43
The insoluble part consists of—				
Calcium and magnesium carbonates	14.02	2.40	14.60	2.50
Calcium sulphate (gypsum)				
Silica	2.98	.51	2.63	.45

Sanitary Analysis.

	Grains per Gallon.	Parts per Million.		
	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.
Mission Creek	1.02	Trace.	.022	1.80
De la Guerra Caisson	1.66	Trace.	.026	1.00
	2.91	.128	.034	1.72

The above waters are quite similar in character. Both are "hard," with 14 grains of carbonates of lime and magnesia per gallon; and the amount of total solid residue is rather large. By removal of the hardness by boiling, the waters could be used for any domestic purpose. The sanitary analysis shows them both to be quite free from organic impurities.

Waters, from Santa Maria, Santa Barbara County; sent by J. F. Goodwin. No. 1 is from that in general use, while that of No. 2 could be introduced if suitable. Both samples were clear and colorless; that of No. 2 contained sulphuretted hydrogen. The composition is as follows:

	No. 1.		No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	58.11	9.95	42.23	7.23
Soluble in water after evaporation	23.83	4.08	12.09	2.07
Insoluble in water after evaporation	24.64	4.22	21.38	3.66
Organic matter and chemically combined water	9.64	1.65	8.76	1.50
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	19.99	3.43	6.39	1.10
Sodium chloride (common salt)	1.36	.23	1.36	.23
Sodium carbonate (sal soda)	2.48	.42	4.34	.74
The insoluble part consists of—				
Calcium and magnesium carbonates	20.21	3.46	17.00	2.91
Calcium sulphate (gypsum)				
Silica	4.43	.76	4.38	.75

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Water No. 1 contains an excessive proportion of mineral salts, and a large part of this is of Glauber's salts and carbonate of magnesia. In No. 2 the Glauber's salts is less than one third of that of No. 1; and, moreover, the amount of lime and magnesia carbonates is less, and these can, for cooking and drinking purposes, be still further diminished by using one twentieth of (clear) lime water to settle them out. No. 2 is materially preferable to the one now in use.

Lake water, of West Lake Park, Los Angeles; sent by P. A. Howard, Assistant Secretary of the Park Commission. The sample was clear, no taste, and slightly alkaline, with an odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	75.93	13.00
Soluble in water after evaporation	48.60	8.32
Insoluble in water after evaporation	13.72	2.35
Organic matter and chemically combined water	13.61	2.33
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	4.33	.75
Sodium chloride (common salt)	43.65	7.46
Sodium carbonate (sal soda)	.62	.11
The insoluble part consists of—		
Calcium and magnesium carbonates	12.38	2.12
Calcium sulphate (gypsum)		
Silica	1.34	.23

The water is too strongly mineral to be used for irrigation, save under special precautions, viz.: the washing out of the accumulated salts, either by underdrainage, or at least once a year by continued flooding, which, in the sandy soil of the region, would probably wash it into the country drainage.

Water, from Lytle Creek, Rialto, San Bernardino County; sent by the Semi-Tropic Land and Water Company. The water is taken from the pipes of the town pressure system, having run about 6 miles in an open ditch, 1½ miles in cement pipes, and the same distance in iron pipes.

	Grains per Gallons.	Parts in 10,000.
Total residue by evaporation	11.95	2.05
Soluble in water after evaporation	3.20	.55
Insoluble in water after evaporation	7.29	1.22
Organic matter and chemically combined water	1.46	0.25
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	Trace.	
Sodium chloride (common salt)	1.92	0.33
Sodium carbonate (sal soda)	1.28	0.22
The insoluble part consists of—		
Calcium and magnesium carbonates	5.83	1.00
Calcium sulphate (gypsum)	Trace.	
Silica	1.46	0.22

The above is a very good water for all domestic purposes. Upon the sandy loam lands of the region the amount of carbonate of soda will do no harm.

Water, from the Sweetwater system, San Diego; sent by H. W. Savage, hydraulic engineer, San Diego Land and Town Company.

"Sample No. 1 was taken from Service No. 92, domestic supply, Sweetwater system, after coming through 7 miles of wrought-iron pipe from

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Sweetwater impounding and storage reservoir. The pipe, which was originally dipped in asphaltum and coal tar dip, has been laid and in constant use about three years. The reservoir is formed by a dam 90 feet high, across the Sweetwater River, 7 miles from San Diego Bay. The top of the dam is 215 feet above mean tide. The Sweetwater River has a drainage area of 186 square miles above the dam, in a very sparsely settled country. Red clay soil constitutes the major portion of the bed of the reservoir basin outside of the old river-bed, and is nearly impervious. The reservoir, when full, flows 700 acres, the lower 300 of which was thoroughly grubbed, and all vegetable matter removed. The remainder of the flowage tract, outside the old river-bed, is covered with a scant growth of weeds, and scrub brush of various kinds. That part of the remainder in the old river-bed has growing on it as omewhat heavy growth of cottonwood and other trees, varying from 2 feet in diameter down. Throughout the summer season of 1889 the reservoir, which impounds 6,000,000,000 gallons, was practically full, and the water was decidedly offensive to both smell and taste, particularly the former. There was also a considerable and constant accumulation of green scum around the outskirts of the reservoir, keeping several men continually employed in removing it. The water was drawn down during the season some 40 feet, or about 95 per cent, leaving 5 per cent in the reservoir. With the beginning of cool weather in the fall, the water suddenly became practically free from both offensive smell and taste.

"During the year 1890 the water was at no time impounded to flow any land outside of the grubbed tract, yet during the summer both offensive smell and taste reappeared, and remained until October and disappeared as suddenly as before.

"The history of the present year is as follows: In February we closed the waste gates, and practically filled the reservoir from the spring flow, flowing ungrubbed land both in the river-bed and the part including scrub and timber-covered portion. In early July the water began to smell and taste bad, and has continued to do so since. Recently it has been improving, and the water in the reservoir throughout the season has generally been clear and almost no scum or foreign matter has appeared. During the summer of 1890 complaint was so strong that we were compelled to supply many customers, at their request, with poor well water, by team, for all domestic purposes, and this season a large number have used the same poor well water for drinking and other domestic purposes, deeming the Sweetwater unhealthy, yet we have no proof, or even a reliable statement, of the least injurious effect in any way to any person or child from using the Sweetwater. Boiling removed, at all times, all apparent offensive smell and taste. Also, if the water be placed in a vessel of any size, from a 30-gallon cask down, and the same left exposed to the action of the air for twenty-four hours without any agitation whatever, the water becomes apparently both pure and wholesome to both smell and taste.

"We furnish water for domestic purposes to between one thousand five hundred and two thousand people, and for irrigating something over 2,000 acres of land. A complete sanitary analysis of sample will be of great public benefit.

"Sample No. 2 was taken from a bored well, which is cased with sheet-iron 4 inches in diameter. The location of the well is the Sweetwater River Valley, 8,250 feet from San Diego Bay. The surface of the ground

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where the well was started is 19 feet above mean tide. The well is 52 feet deep, consequently the bottom of the well is 33 feet below mean tide. In sinking the well, the first 40 feet was through medium sand, the next 10 feet was brown clay, changing to blue as the bottom of the stratum was reached. The next 2 feet, after getting through the clay, was very coarse gravel, changing in the next and last 2 feet to cobblestones and small bowlders. Water was first struck and constantly stands in the well at an elevation of about 6 feet below the surface of the ground. The entrance of the supply pipe to the pump from which this water was obtained is 40 feet high from the surface of the ground. There is no apparent escaping gas. We have just bored the well and placed the pump, and the general public accepts the water, and uses it for domestic purposes as a satisfactory substitute for the Sweetwater gravity supply. An analysis will inform the public, and ourselves, if this well water is a desirable water for domestic purposes, and if it is necessary or advisable to use it as a substitute for the Sweetwater."

The waters have the following composition:

	Service, from No. 92.		Bored Well.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	17.35	2.97	31.13	5.33
Soluble in water after evaporation	7.77	1.33	18.28	3.13
Insoluble in water after evaporation	7.54	1.29	11.39	1.95
Organic matter and chemically combined water	2.04	.35	1.46	.25
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	3.44	.59	8.58	1.47
Sodium chloride (common salt)	2.73	.47	7.50	1.28
Sodium carbonate (sal soda)	1.60	.27	2.20	.38
The insoluble part consists of—				
Calcium and magnesium carbonates	5.26	.90	8.64	1.48
Calcium sulphate (gypsum)				
Silica	2.28	.39	2.75	.47

Sanitary Analysis.

	Grains per Gallon.	Parts per Million.		
	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.
Service water	1.65	.040	.186	4.00
Bored well	4.54	.128	.100	1.87

As regards the total mineral matter, it is nearly the same in amount, and not much different in quality, from the water of the Los Angeles River, as taken from the service pipes in the city. From an outside point of view it might be thought that it contains a rather large amount of common salt, which is usually taken to indicate sewage contamination; but considering the usual composition of waters in that region, that item cannot be regarded in the same light as it would in the East, any more than can the fact that the water of the well contains more than twice as much salt be similarly interpreted, such contamination being out of the question in that case. The saline contents are not

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such as would create any presumption against the water if by themselves. The real cause of the trouble is in the carbonate of soda, which tends to make the organic matter present to undergo a fetid fermentation that, in the absence of that substance, would remain imperceptible. This results in the formation of some sulphuretted hydrogen, which is probably the chief cause of the evil odor that has been observed.

Of course, this fermentation could not happen but for the presence of a relatively large proportion of organic matter; and for this the water is undoubtedly indebted to the ungrubbed portion of the ground. The carbonate of soda helps to dissolve more of that matter than would otherwise be the case. During the cool weather the fermentation cannot proceed, hence the odor disappears, to reappear when warm weather sets in the next season.

As to the character and possible noxiousness of that vegetable matter, the determination of ammonia and "oxygen consumed" gives some light. "Free ammonia" is found only to the extent of 0.040 per cent; the admissible limit is 0.100 per cent, therefore it is quite within the limits. The bored well water contains more. The showing for the "albuminoid ammonia" is not so satisfactory. The limit for ordinary drinking water is set down as 0.100 per cent, which is the figure for the well water in this case, while the reservoir water goes nearly double in this regard. In the East, and in Europe, the reservoir would therefore be condemned as unfit for domestic use on that score; and there would be good reason for it, for it would there indicate sewage contamination. That it does so in this case is unlikely from the nature of the case. The carbonate of soda in the water acting upon the vegetable debris left within the reservoir explains the matter very naturally. But whether or not the water is, on that account, to be considered unhealthy, is a question for which there is no absolute precedent. It is certainly not as though it were contaminated with animal matter or sewage; the water is not virulent, even though it may be offensive during warm weather. If flowing, and aerated thereby, it would not acquire such odor at all; the trouble is that it is stagnant.

The item "oxygen consumed" tells the same story. It indicates the total amount of organic matter present, and the figure (four parts in a million) is just at the limit beyond which the water would pass from the class of "doubtful purity" to that of inadmissible, contaminated waters. This estimate is again, however, based upon the supposition that the contamination may arise from refuse or sewage, while in this case it arises plainly from the solvent action of the carbonate of soda upon the chaparral left in the upper portion of the reservoir.

The well water is still within the limits of potable waters, so far as mineral contents go. Most people would not be affected by it, and, therefore, it being undoubtedly safe, should prefer it to the other, especially if unfiltered. (E. W. H.)

B. SPRING WATERS.

Water; sent by P. H. Wallace, of Pope Valley, Napa County.

"It comes out of a hill where there are outcroppings of stone coal; supposed to have oil on its surface."

Only a small bottle of water was sent. It had a scum of iron oxide

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on the surface, and hence is rather chalybeate in character. No oil present.

Water, from a tunnel on west side of Napa Valley, near Oakville; sent by J. Benson, of San Francisco. The sample was clear, without taste or odor, and had the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	19.27	3.30
Soluble in water after evaporation	5.96	1.02
Insoluble in water after evaporation	10.98	1.88
Organic matter and chemically combined water	2.33	.40
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	4.58	.79
Sodium chloride (common salt)	.14	.02
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	9.52	1.63
Silica	1.46	.25

The water is entirely unobjectionable for domestic use, both as to quantity and quality of mineral ingredients. It is somewhat hard, but that can, if desired, be obviated by boiling, or by treatment with one twentieth of its bulk of lime water, and letting it settle.

Spring water, from Rincon Heights Olive Farm, Santa Rosa; sent by Guy E. Groose.

"The spring is about 200 feet above the valley, and the water empties direct into a cement reservoir. Thence it is distributed through galvanized iron pipes to the winery and buildings. It is very soft for washing purposes and eagerly sought for by both animals, man, and birds for drink. In the sunlight the water in the water-trough has a bluish-white appearance."

The water is clear, tasteless, and odorless, and has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	5.84	1.00
Soluble in water after evaporation	1.75	.30
Insoluble in water after evaporation	3.21	.55
Organic matter and chemically combined water	.88	.15
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.32	.05
Sodium chloride (common salt)	.82	.14
Sodium carbonate (sal soda)	.61	.11
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	1.17	.20
Silica	2.04	.35

The water is exceptionally pure in character, and excellent for all domestic and irrigation purposes.

Water, from Salt Spring Valley, Milton, Calaveras County; sent by J. S. Pedroli. The sample was clear, with a straw-yellow color and an odor of sulphuretted hydrogen. Its composition is as follows:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	160.04	27.40
Soluble in water after evaporation	141.00	24.14
Insoluble in water after evaporation	7.36	1.26
Organic matter and chemically combined water	11.68	2.00
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	31.72	5.45
Sodium chloride (common salt)	57.29	9.79
Sodium carbonate (sal soda)	51.99	8.90
The insoluble part consists of—		
Calcium and magnesium carbonates	6.42	1.10
Calcium sulphate (gypsum)		
Silica	.94	.16

The water contains too much mineral matter, and especially of soluble salts, for either domestic or irrigation uses. The carbonate of soda, or "black alkali," percentage is very high.

Water, from spring in a cañon of Willow Creek, on the land of H. Lipscomb, 16 miles south of Tres Pinos, San Benito County; sent by H. Lipscomb, of San Francisco.

The water contains 274.88 grains of mineral salts per gallon. These comprise a very large amount of magnesium sulphate (Epsom salts) and chloride of sodium (common salt), much gypsum and silica. The analysis shows the water to be entirely unfit for domestic use, being strongly purgative and sure to be hurtful to both man and beast, if its use is persisted in.

Spring water, from Cupertino; sent by J. J. Scharff.

"The spring is found in a cañon near here, and runs in a little streamlet at the rate of 75 to 100 gallons per day. The little reservoir is covered with a thin sheet of white sulphur crust. The surrounding air smells of sulphuretted hydrogen; the taste of the water is somewhat bitter and from its effect probably contains Epsom salts."

The sample was clear, yellowish green in color and gave a strong odor of sulphuretted hydrogen; it had a bitter taste, and alkaline reaction. Its composition was found to be as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	60.80	10.41
Soluble in water after evaporation	30.67	5.25
Insoluble in water after evaporation	20.38	3.49
Organic matter and chemically combined water	9.75	1.67
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	21.62	3.70
Sodium chloride (common salt)	4.09	.70
Sodium carbonate (sal soda)	4.96	.85
The insoluble part consists of—		
Calcium and magnesium carbonates	19.45	3.33
Calcium sulphate (gypsum)		
Silica	.93	.16

The water has a large amount of sulphuretted hydrogen.

The amount of mineral matter, and especially of soluble salts, is too large to make the water suitable for domestic purposes. It is also "hard" in character, but this could be corrected by boiling.

Spring water, from San Miguel; sent by L. H. Mead.

"Everything around the spring is covered with what resembles yellow

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ochre. The water tastes like tincture of iron. It comes out of a shell limestone, but the hills back of it are of sandstone. There is a coal mine 6 miles distant."

The water is clear, with a chalybeate taste. It has the following composition:

	Grains per Gallon.
Total residue	152.45
Organic matter and water of combination	10.92
Soluble in water	81.54
Insoluble in water	59.99

The soluble part consists of Glauber's salt (sodium sulphate), with a small amount of potassium and magnesium sulphates, and sodium chloride (common salt), and considerable sulphate of iron. The insoluble part is mainly gypsum, some iron, and a little silica. There is some free sulphuric acid present in the water, which gives it an acid reaction. The amount of mineral matter in this water is too large to make its use advisable, either for domestic or irrigation purposes.

Water, from a spring 2 miles from Santa Barbara; sent by Henry Clifton. The water is clear, and without taste or odor. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	29.38	5.03
Soluble in water after evaporation	8.76	1.50
Insoluble in water after evaporation	14.43	2.47
Organic matter and chemically combined water	6.19	1.06
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.40	.59
Sodium chloride (common salt)	1.64	.28
Sodium carbonate (sal soda)	3.72	.63
The insoluble part consists of—		
Calcium and magnesium carbonates	14.43	2.47
Calcium sulphate (gypsum)		
Silica		

This is simply a very hard water, suitable for domestic use in most cases, except that for washing; it must be first boiled, or sal soda used to do away with the excessive hardness.

Spring water; sent by W. A. Hawley, of Santa Barbara. It is similar to that sent by Hon. E. H. Heacock, and whose analysis appears in the Report for 1890; the springs are, however, a long distance apart. The water yields on evaporation, 2,418.2 grains per gallon, of which 1,398 grains is of nitrate of magnesia. The remainder is largely of chloride of sodium (common salt), sulphates of soda and potash, and a small amount of lime. The occurrence of so much nitrate of magnesia in springs situated in such a climate is most extraordinary.

Spring waters, from Piru Ranch, Ventura County; sent by David C. Cook, of Los Angeles. Both samples were clear, colorless, and odorless.

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	Spring No. 1.		Spring No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	78.79	13.49	86.90	14.88
Soluble in water after evaporation	25.93	4.44	39.72	6.80
Insoluble in water after evaporation	45.03	7.71	39.59	6.78
Organic matter and chemically combined water	7.83	1.34	7.59	1.30
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	25.11	4.30	36.76	6.30
Sodium chloride (common salt)	.34	.06	.48	.08
Sodium carbonate (sal soda)	.48	.08	2.48	.42
The insoluble part consists of—				
Calcium and magnesium carbonates, Calcium sulphate (gypsum), chiefly	41.76	7.15	36.44	6.24
Silica	3.27	.56	3.15	.54

The amount of solid contents per gallon, in both waters, is very large, and would alone condemn them for use. But, in addition, they are made purgative by the presence of a large amount of Glauber's salt. There is also some magnesium sulphate (Epsom salts) in the waters to add to this effect.

Water, flowing from a coal tunnel on the Fresno side of the mountains; sent by A. J. Robinson, of the Mineral Land Agency, San Francisco. The water is clear and colorless, but with a flat, insipid taste. It has the following composition:

	Grains per Gallon.
Total residue by evaporation	483.42
Organic matter and water of combination	48.83
Soluble in water after evaporation	373.84
Insoluble in water after evaporation	60.75

The soluble part consists chiefly of sodium sulphate (Glauber's salt) and magnesium sulphate (Epsom salts); small amounts of potassium sulphate and sodium carbonate (sal soda), and sodium chloride (common salt). The insoluble part consists of calcium and magnesium carbonates, gypsum, and a small amount of silica. The amount of mineral matter, and especially of soluble salts, is too great for either domestic or irrigation uses.

Water, from spring near Newhall, Los Angeles County; sent by Messrs. Jory Bros., of San Francisco.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	224.64	38.45
Soluble in water after evaporation	212.91	36.45
Insoluble in water after evaporation	4.14	.70
Organic matter and chemically combined water	7.59	1.30
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	71.37	12.23
Sodium chloride (common salt)	125.45	21.47
Sodium carbonate (sal soda)	16.09	2.75
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum), Silica	4.14	.70

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The mineral contents are ten times greater than would be admissible for domestic use; it is a saline, purgative water, toned down a little from too great harshness by the carbonate of soda.

Water, from a mountain cañon 2 miles north of Etiwanda, San Bernardino County; sent by Dr. O. S. Winstanley.

"The water supplies the colony, and is said to come directly in a full stream from the rocks, and is joined in its further course by streamlets from a swampy or springy mesa, and brought down by a wooden flume."

The composition of the water is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	9.75	1.67
Soluble in water after evaporation	.48	.08
Insoluble in water after evaporation	6.53	1.12
Organic matter and chemically combined water	2.74	.47
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salts, etc.)	.28	.05
Sodium chloride (common salt)	Trace.	
Sodium carbonate (sal soda)	.20	.03
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	4.78	.82
Silica	1.75	.30

The water is rather exceptionally pure, as it contains only half a grain of permanently soluble matter. There is very little potash, and the trifle of carbonate of soda is of no consequence. The unusual amount of organic matter doubtless comes from the swampy springs mentioned above.

C. COMMON WELL WATERS.

Mineral water, from Vacaville; sent by Messrs. Tucker & Tubbs. The water has an earthy taste and an odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	320.27	54.83
Soluble in water after evaporation	290.88	49.80
Insoluble in water after evaporation	20.90	3.58
Organic matter and chemically combined water	8.49	1.45
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	283.74	48.58
Sodium chloride (common salt)	.95	.16
Sodium carbonate (sal soda)	6.19	1.06
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	16.82	2.88
Silica	4.08	.70

This water is entirely unfit for either domestic or irrigation uses, not only because of its very large amount of total mineral matter, but from the presence of so large a proportion of Glauber's salt.

Well water, from near Dwight Way, Berkeley; sent by Prof. A. Putzker. It was supposed to have been the cause of typhoid fever in his family. The water was clear and without taste or odor. It contained only 17.52

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grains of mineral salts per gallon, of which 1.65 was of chlorine. In 1,000,000 parts there were but 0.005 of free ammonia and 0.096 of albuminoid ammonia. The small amount of the latter shows that the water is free from contamination with sewage matter.

Water, from an artesian well on the place of Mrs. Calhoun, on Dwight Way, Berkeley, from which the adjoining school receives its supply.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	22.45	3.84
Soluble in water after evaporation	8.70	1.49
Insoluble in water after evaporation	8.47	1.45
Organic matter and chemically combined water	5.26	.90
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.93	.50
Sodium chloride (common salt)	2.05	.35
Sodium carbonate (sal soda)	3.72	.64
The insoluble part consists of—		
Calcium and magnesium carbonates	4.38	.75
Calcium sulphate (gypsum)		
Silica	4.09	.70

Sanitary Analysis.

Free ammonia	.016 parts per million.
Albuminoid ammonia	.031 parts per million.

The amount of mineral matter in this water is comparatively small and unobjectionable, and about evenly divided between soluble and insoluble salts. The sal soda present neutralizes its tendency to hardness. The sanitary analysis shows freedom from sewage contamination, which was charged against it.

Well water, from South Berkeley; sent by Hugh Forgie. The well is from 54 to 62 feet deep; the flow of water 3,000 gallons per day at first, but decreased one third in six months. The 7-inch boring went through 50 feet of clay, and reached water in fine sand. The water was clear, but with a musty taste. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	16.06	2.75
Soluble in water after evaporation	6.14	1.05
Insoluble in water after evaporation	7.88	1.35
Organic matter and chemically combined water	2.04	.35
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.56	.27
Sodium chloride (common salt)	2.72	.46
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	6.19	1.06
Calcium sulphate (gypsum)		
Silica	1.69	.29

The water does not differ in any important respect from the common well waters of this region, except that it is perhaps a little less mineral han most of them.

Well water, from Haywards, Alameda County; sent by C. P. Nettleton. Sample was clear, with no taste, color, or odor. Its composition is as follows:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	35.75	6.12
Soluble in water after evaporation	15.89	2.72
Insoluble in water after evaporation	17.35	2.97
Organic matter and chemically combined water	2.51	.43
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	6.59	1.13
Sodium chloride (common salt)	6.82	1.17
Sodium carbonate (sal soda)	2.48	.42
The insoluble part consists of—		
Calcium and magnesium carbonates	12.56	2.15
Calcium sulphate (gypsum), small amount		
Silica	4.79	.82

The mineral contents of the water are rather high, and it is very "hard," but persons will doubtless become accustomed to its use. For irrigation it can be used on sandy soils where the alkali will not accumulate.

Water; sent by William Rutherford, Superintendent of Oakland Cotton Mills. The specimen is turbid, but without taste or odor. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	13.02	2.23
Soluble in water after evaporation	3.97	.68
Insoluble in water after evaporation	5.66	.97
Organic matter and chemically combined water	3.39	.58
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.75	.13
Sodium chloride (common salt)	1.36	.23
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates, chiefly	5.25	.90
Calcium sulphate (gypsum)		
Silica	.41	.07

This is an unusually pure water for the coast region, and it is doubtful if anything better can be found.

Well water, from old and new wells of the Cotton Mills, East Oakland; sent by William Rutherford, for examination with respect to their adaptation to use in steam boilers. The samples were clear, with no taste or odor, but a slightly alkaline character. Their composition is as follows:

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	Old Well.		New Well.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	36.91	6.32	16.12	2.76
Soluble in water after evaporation	11.10	1.90	4.67	.80
Insoluble in water after evaporation	15.49	2.65	9.11	1.56
Organic matter and chemically combined water	10.32	1.77	2.34	.40
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	5.89	1.01	1.45	.25
Sodium chloride (common salt)	2.73	.47	1.36	.23
Sodium carbonate (sal soda)	2.48	.42	1.86	.32
The insoluble part consists of—				
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	14.89	2.55	7.24	1.24
Silica	.60	.10	1.87	.32

There is a notable difference in the mineral contents of the "old" and "new" wells, respectively. The old well contains just about double the amount of mineral, and almost exactly double the amount of earthy, matter; and the larger proportion of sulphates contained in it would contribute greatly toward making a troublesome scale. The water of the new well would be a great improvement on that of the old.

Water, from a well on the place of General Vail, at Brentwood, Contra Costa County; brought by William Denman, class of 1894, University of California. The sample was slightly turbid with large flakes of silica; has a flattish taste and odor as of vinegar. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	92.58	15.85
Soluble in water after evaporation	51.63	8.84
Insoluble in water after evaporation	31.08	5.32
Organic matter and chemically combined water	9.87	1.69
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	29.25	5.02
Sodium chloride (common salt)	21.14	3.61
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	30.49	5.22
Silica	.59	.10

The water is too strong in mineral matter for domestic use, or for cattle, being purgative and sure to produce disturbed digestion. In very sandy, well-drained soils it might serve for irrigation, if used abundantly.

Water, from L. J. Fish, Martinez; to be examined for sewage contamination. The water contains 33.5 grains per gallon. There is but a small amount of free ammonia present, and is therefore free from contamination.

Water, from a well at Colonia, Ventura County; sent by J. E. Bonbard, Ventura. The sample was without taste, color, or odor. Its composition proved to be as follows:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	56.31	9.64
Soluble in water after evaporation	28.91	4.95
Insoluble in water after evaporation	21.90	3.75
Organic matter and chemically combined water	5.50	.94
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	22.46	3.85
Sodium chloride (common salt)	2.73	.46
Sodium carbonate (sal soda)	3.72	.64
The insoluble part consists of—		
Calcium and magnesium carbonates	18.75	3.21
Calcium sulphate (gypsum), large amount		
Silica	3.15	.54

The large amount of mineral matter in this water, and especially of Glauber's and other soluble salts, makes it unfit for drinking purposes. It will do for irrigation on well-drained, sandy soils, but on clayey land will in time give rise to "black alkali."

Water, from wells in Gonzales, Monterey County, used for domestic purposes; sent by J. G. Ramsey. Well No. 1 was 30 feet deep. Well No. 2, five miles from Gonzales, was 100 feet deep. Both waters were clear, colorless, tasteless, and odorless.

	Well No. 1.		Well No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	40.89	7.00	35.05	6.00
Soluble in water after evaporation	22.49	3.85	17.53	2.90
Insoluble in water after evaporation	15.48	2.65	9.52	1.65
Organic matter and chemically combined water	2.92	.50	8.00	1.37
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	8.73	1.50	7.87	1.35
Sodium chloride (common salt)	10.92	1.86	8.18	1.40
Sodium carbonate (sal soda)	2.84	.49	1.48	.25
The insoluble part consists of—				
Calcium and magnesium carbonates	12.38	2.12	7.19	1.23
Calcium sulphate (gypsum)				
Silica	3.10	.53	2.33	.40

Sanitary Analyses.

	Grains per Gallon.		Parts per Million.	
	Total Residue.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.
Well No. 1, 30 feet deep, in town of Gonzales	40.89	6.66	.024	.032
Well No. 2, 100 feet deep, 5 miles from Gonzales	35.05	4.99	.120	.042

The amount of soluble salts in the above waters is too large for continued domestic use, and would soon prove injurious. The same is true if used for irrigation; the soil would soon become charged with salts, and the carbonate of soda would produce "black alkali," unless drainage

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facilities were perfect for the removal of these salts. The water from the well No. 2, taken at 100 feet, is the better of the two. The "sanitary analysis" shows both waters to be quite free from sewage matters.

Well water, from a valley 5 miles west of Santa Barbara, and 3 miles from sea-shore, and elevated about 50 feet above sea-level; sent by Joseph J. Perkins, Santa Barbara.

"The well is about 10 feet deep, and the sample of water from it has been standing in the well for about three weeks. The soil on which the water is to be used for irrigation is a fine, rich, sandy loam, except a small patch, on which there is some appearance of alkali in dry weather, but the whole tract has been cultivated for ten or more years, and crops of corn, squashes, and beans grown thereon. Is the water good for irrigating citrus fruit trees?"

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	46.73	8.00
Soluble in water after evaporation	16.71	2.86
Insoluble in water after evaporation	18.81	3.22
Organic matter and chemically combined water	17.21	1.92
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	6.32	1.09
Sodium chloride (common salt)	5.44	.92
Sodium carbonate (sal soda)	4.95	.85
The insoluble part consists of—		
Calcium and magnesium carbonates	17.52	3.00
Calcium sulphate (gypsum)		
Silica	1.29	.22

The total amount of mineral matter in the above water is rather high for irrigation purposes, and there is danger that the carbonate of soda would by accumulation produce "black alkali," unless the soil were carefully drained.

Well water, from Southern Coast Range Station, Paso Robles, San Luis Obispo County.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	24.91	4.625
Soluble in water after evaporation	11.10	1.900
Insoluble in water after evaporation	11.39	1.960
Organic matter and chemically combined water	2.42	.415
The soluble part consists of—		
Potassium sulphate	2.80	.480
Sodium sulphate	.76	.130
Sodium chloride	5.96	1.020
Sodium carbonate	1.50	.270
Magnesium sulphate	Traces.	Traces.
The insoluble part consists of—		
Calcium sulphate	.56	.095
Calcium carbonate	5.37	.920
Magnesium carbonate	2.68	.460
Silica	2.78	.475

This water is, in solid contents, within the limits for domestic uses, though perhaps rather "hard" from the calcium and magnesium carbonates. It is also very well adapted for irrigation purposes.

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Well water, from Millsholm, Colusa County; sent by Robert Mack, San Francisco. The sample was clear and without taste or odor. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	20.09	3.44
Soluble in water after evaporation	7.89	1.35
Insoluble in water after evaporation	8.52	1.46
Organic matter and chemically combined water	3.68	.63
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.97	.35
Sodium chloride (common salt)	.96	.16
Sodium carbonate (sal soda)	4.96	.84
The insoluble part consists of—		
Calcium and magnesium carbonates	7.24	1.24
Calcium sulphate (gypsum)		
Silica	1.28	.22

The water is entirely unobjectionable for domestic use; its content of carbonate of soda will tend to prevent any possible purgative action of the other mineral ingredients, which are, however, in very moderate quantity. The small porportion of common salt present shows absence of sewage contamination.

Well water, from Sausalito, Marin County; sent by Thomas Ryan. The well is on Princess Avenue. The water was struck in a gravel bed, at 25 feet, apparently a slide in strata, and the flow is about 300 gallons in twenty-four hours. The sample was clear, with a salty taste and acid reaction. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	73.01	12.50
Soluble in water after evaporation	40.59	6.95
Insoluble after evaporation	25.71	4.40
Organic matter and chemically combined water	6.71	1.15
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	10.46	1.81
Sodium chloride (common salt)	28.64	4.89
Sodium carbonate (sal soda)	1.49	.25
The insoluble part consists of—		
Calcium and magnesium carbonates	19.87	3.40
Calcium sulphate (gypsum)		
Silica	5.84	1.00

This is a saline water of moderate strength and slightly purgative properties, imparted to it by the Glauber's salt and magnesia carbonate. Its chief ingredient, as will be noted, is common salt, which forms three fourths of the soluble salts. The water is too hard and too strongly mineral for domestic use.

Well water, from John S. Lindner, Paso Robles, San Luis Obispo County. The well is 130 feet deep. The sample was clear, tasteless, and colorless. Its composition proved to be as follows:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	261.50	44.77
Soluble in water after evaporation	197.78	33.86
Insoluble in water after evaporation	49.59	8.49
Organic matter and chemically combined water	14.13	2.42
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	192.82	33.01
Magnesium and calcium chlorides		
Sodium chloride (common salt), chiefly		
Sodium carbonate (sal soda)	4.96	.85
The insoluble part consists of—		
Calcium and magnesium carbonates	46.61	7.98
Calcium sulphate (gypsum), chiefly		
Silica	2.98	.51

This water is strongly saline, containing a large amount of mineral matter, the greater part of which is common salt. It is, of course, entirely unfit for either domestic or irrigation uses.

Well water, from Saticoy, Ventura County; sent by R. G. Pardee.

"The water becomes yellowish and turbid if allowed to stand in an iron pipe over night, though clear when freshly pumped from the well."

The sample is clear and colorless, with an odor of sulphuretted hydrogen and an alkaline reaction. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	69.10	11.78
Soluble in water after evaporation	31.54	5.40
Insoluble in water after evaporation	30.26	5.13
Organic matter and chemically combined water	7.30	1.25
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	27.63	4.73
Sodium chloride (common salt)	2.05	.35
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	25.41	4.30
Calcium sulphate (gypsum), chiefly		
Silica	4.85	.83

Like most of the waters of that region, this is quite high in mineral contents, the chief being the purgative salts, Glauber's and gypsum. It is properly a mineral water, especially as it contains sulphuretted hydrogen and carbonic gas. These latter are the cause of the turbidity and subsequent black deposit after the water stands in the iron pipe, as the iron is attacked and then on exposure to the air the black iron sulphide is formed; in other words, it becomes a chalybeate water on standing in the pipe.

Water, from Piru City, Ventura County; sent by A. L. Chaffee. The spring issues from the mountain side, about 700 feet above sea-level, and about 2 miles south of Piru City. The water is clear, tasteless, with no odor; slightly alkaline.

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	155.96	26.70
Soluble in water after evaporation	65.42	11.20
Insoluble in water after evaporation	66.30	11.35
Organic matter and chemically combined water	24.24	4.15
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	58.23	9.97
Sodium chloride (common salt)	2.55	.44
Sodium carbonate (sal soda)	4.64	.79
The insoluble part consists of—		
Calcium and magnesium carbonates	62.56	10.71
Calcium sulphate (gypsum)		
Silica	3.74	.64
The spectroscope shows faint traces of lithia.		

The mineral contents in this water are so high as to render it unfit for domestic uses, including irrigation; no land could long stand the addition of alkali that would be made by this water, nor could any person long resist the debilitating influence of such doses of Glauber's salt and earthy salts—gypsum included. The trace of lithia shown by the spectroscope is not enough to contribute to its medicinal value. The extreme hardness of the water can, of course, be mitigated by the use of sal soda in washing.

Well water, from La Paloma Vineyard and Stock Farm, Fresno; sent by Robert Good. The sample was too small to determine the proportions of its ingredients. The water is milky in appearance, from suspended clay, and on evaporating to dryness gave a residue equal to about 17 grains per gallon. This residue contained but a trace of chlorides and sulphates, some carbonate of soda. The soluble salts probably amount to not more than 12 grains per gallon, and the water is very good for domestic purposes.

Water, from Bates, Fresno County; sent by Mrs. Lena Miller. The water contained but 16.35 grains of mineral matter per gallon, and is chiefly a "hard" water, with some common salt. It can therefore be used for domestic purposes; if too "hard" for washing, it can be softened by boiling or the use of sal soda.

Water, from a well 40 feet deep; sent by H. A. Hart, Natick House, Los Angeles. The sample was clear, colorless, and without odor. Its composition was found to be:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	61.09	10.46
Soluble in water after evaporation	34.81	5.96
Insoluble in water after evaporation	22.66	3.88
Organic matter and chemically combined water	3.62	.62
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	22.66	3.88
Sodium chloride (common salt)	10.91	1.87
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	21.55	3.69
Calcium sulphate (gypsum)		
Silica	1.11	.19

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The water contains more mineral matter than is regarded as safe in potable waters. More than half of its contents is of soluble salts, which would have a weakening effect on any person using the water. The water is therefore not suitable for domestic use.

Water, from a well on the land of W. R. Nutting, 7 miles southwest of Fresno. The water has the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	132.30	22.65
Soluble in water after evaporation	93.75	16.05
Insoluble in water after evaporation	12.27	2.10
Organic matter and chemically combined water	26.28	4.50
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	4.43	.78
Sodium chloride (common salt)	42.28	7.22
Sodium carbonate (sal soda)	47.04	8.05
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	10.80	1.85
Silica	1.47	.25

The water has not only too much mineral matter in for any use, either domestic or irrigation, but is very strongly charged with carbonate soda, or "black alkali."

Well water, from the Rosedale Colony, Kern County; sent by D. O. Anderson, San Francisco.

"The colony is composed of many people from Illinois, Indiana, Ohio, and England, and it is thought that the water acts as a mild cathartic on new-comers. The well is 50 feet deep."

The water is clear and tasteless. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.32	2.11
Soluble in water after evaporation	5.66	.97
Insoluble in water after evaporation	5.02	.86
Organic matter and chemically combined water	1.64	.28
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.83	.31
Sodium chloride (common salt)	1.36	.23
Sodium carbonate (sal soda)	2.47	.43
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	3.09	.53
Silica	1.93	.33

The water is quite pure, and suitable for domestic purposes, as well as for irrigation. The amount of carbonate of soda is so small that it would require some time to accumulate, even on heavy soils, sufficiently to produce "black alkali."

Well water, from two wells in the bottoms of Santa Ana River; sent by C. T. Hopkins, Pasadena.

"The water of No. 1 stands 5 feet below the surface in summer and 3 feet in winter. That of No. 2, 3 feet in summer and 15 inches in winter. The wells are one half mile apart."

The samples were clear and without taste or odor. Their composition is as follows:

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	Deep Well. 5 feet below surface.		Shallow Well. Near surface.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	42.06	7.20	159.34	27.28
Soluble in water after evaporation	22.78	3.90	107.24	18.36
Insoluble in water after evaporation	16.36	2.80	37.50	6.42
Organic matter and chemically combined water	2.92	.50	14.60	2.50
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	13.86	2.38	92.62	15.86
Sodium chloride (common salt)	2.72	.46	10.90	1.86
Sodium carbonate (sal soda)	6.20	1.06	3.72	.64
The insoluble part consists of—				
Calcium and magnesium carbonates	14.60	2.50	35.16	6.02
Calcium sulphate (gypsum)				
Silica	1.76	.30	2.34	.40

There is a wide difference between the water of the well where it is at the surface and in that where it is from 3 to 5 feet below the surface; the alkali has sought the surface as usual and stays there, and thus there is four times as much in the shallow well as in the deeper one. The alkali in the latter is moderately "black," that in the other is not bad—almost white.

Well water, from the foothills west of Orlando, Glenn County; sent by Thos. L. Knock.

"The water has a queer taste, and deposits a hard, black scale on iron if left for a time in the water."

The sample was turbid from the presence of flocculent ferric hydrate. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	120.5	20.59
Soluble in water after evaporation	92.2	15.78
Insoluble in water after evaporation	16.4	2.81
Organic matter and chemically combined water	11.9	2.00
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	31.3	5.45
Magnesium sulphate (Epsom salts)	16.3	2.70
Sodium chloride (common salt)	40.9	7.00
Sodium carbonate (sal soda)	3.7	.63
The insoluble part consists of—		
Calcium and magnesium carbonates	16.0	2.75
Calcium sulphate (gypsum)		
Silica	.4	.06

The water is altogether too strongly mineral for domestic use; it is a slightly chalybeate and purgative saline water, sufficiently strong for medicinal use when wanted.

Waters, from the Wedge and Melvina wells of the copper region, Bisbee, Arizona; sent by Rev. J. B. McNally, Oakland.

The Wedge well water contains 20.5 grains of mineral salts per gallon; soluble in water after evaporation, 11.7 grains; insoluble, 8.8 grains.

The Melvina water contains 18.3 grains of mineral salts per gallon,

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which are chiefly of earthy carbonates. Amount soluble in water after evaporation, 7.2 grains; insoluble, 11.1 grains.

Both waters are therefore hard in character but suitable for domestic purposes. They can easily be softened for washing purposes by addition of sal soda, and for drinking, by boiling or addition of lime.

D. ARTESIAN WATERS.

Water, from well in Sacramento; sent by W. W. Pulman. The well is 800 feet in depth.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	46.18	7.91
Soluble in water after evaporation	20.61	3.53
Insoluble in water after evaporation	11.97	2.05
Organic matter and chemically combined water	13.60	2.33
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	14.66	2.51
Sodium chloride (common salt)	4.09	.70
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	8.76	1.50
Calcium sulphate (gypsum)		
Silica	3.21	.55

The amount of mineral matter in this water is not only too great for domestic use, but composed as it is, largely of sulphates of the alkalies, the effect upon the system of any one using it would be very debilitating. Its use for irrigation cannot be recommended, except upon well-drained, sandy soils, where the salts could be continually leached out.

Artesian waters, from the water supply of Santa Barbara; sent by Dr. F. M. Casal, Health Officer; taken from a hillside well.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	30.60	5.24
Soluble in water after evaporation		
Insoluble in water after evaporation		
Organic matter and chemically combined water	2.92	.50
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	10.78	1.85
Sodium chloride (common salt)	4.77	.82
Sodium carbonate (sal soda)	2.84	.48
The insoluble part consists of—		
Calcium and magnesium carbonates	4.91	.84
Calcium sulphate (gypsum)		
Silica	4.38	.75

The above water is rather "hard" in character, but can be corrected by boiling. The amount of solid matter on evaporation is a little larger than is desirable for domestic uses, though hardly injurious to health. The sulphates of sodium and potassium would doubtless have some effect upon weak stomachs if used freely.

Well water, from the Jackson gas well at Stockton; sent by John Jackson. The well is about 1,670 feet deep. The sample was very slightly turbid, with a sweetish, brackish taste, but no odor; very slightly alkaline. Composition as follows:

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	164.84	28.22
Soluble in water after evaporation	133.99	22.94
Insoluble in water after evaporation	10.35	1.77
Organic matter and chemically combined water	20.50	3.51
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	132.13	22.62
Magnesium and calcium chlorides		
Sodium chloride (common salt), chiefly		
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	9.87	1.69
Calcium sulphate (gypsum)		
Silica	.48	.08

The water agrees entirely in its general character with that heretofore received from several of the Stockton gas wells; being substantially that of slightly brackish tide-water, changed by maceration in the depths of the valley deposits. It is nearly three times as strong in salts as the Asylum gas well, but one fourth less than the Salmon well.

Water, from the artesian well of the Insane Asylum at Stockton; taken at a depth of 1,664 feet, and sent by the Medical Superintendent, Dr. H. N. Rucker. The composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	297.31	50.90
Soluble in water after evaporation	231.71	39.67
Insoluble in water after evaporation	9.06	1.55
Organic matter and chemically combined water	56.54	9.68
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salts, etc.)	8.26	1.49
Sodium chloride (common salt)	220.97	37.75
Sodium carbonate (sal soda)	2.48	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	3.50	.60
Calcium sulphate (gypsum)		
Silica	5.56	.95

The water is by far too salty to be used for irrigation purposes, as was intended.

Artesian water, from Rialto, San Bernardino County; sent by the Semi-Tropic Land and Water Company. The water is from the pipe-line where it passes through the town; having run for about one half a mile in a tightly covered redwood flume, and two miles in cement pipes.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.73	2.18
Soluble in water after evaporation	3.62	.62
Insoluble in water after evaporation	6.84	1.00
Organic matter and chemically combined water	3.27	.56
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salts, etc.)	Trace.	.....
Sodium chloride (common salt)	Trace.	.....
Sodium carbonate (sal soda)	3.62	.62
The insoluble part consists of—		
Calcium and magnesium carbonates	4.67	.80
Calcium sulphate (gypsum)	Trace.	.....
Silica	1.17	.20

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This is very good water for all domestic uses. The amount of carbonate of soda would have a tendency to accumulate as "black alkali" upon heavy, ill-drained soils, but on the sandy loams of the region it would probably pass rapidly through into the country drainage.

Water of an artesian well, from San Gabriel, Los Angeles County; sent by A. B. Chapman.

"This well is one of many that occupy a belt reaching along the foothills from Baldwin's Santa Anita Rancho, westerly for 7 miles to and inclosing a large part of South Pasadena. Is the water good for domestic and irrigation purposes? How much potash does it give to the soil?"

The water is clear, colorless, tasteless, and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	13.73	2.35
Soluble in water after evaporation	2.98	.51
Insoluble in water after evaporation	8.47	1.45
Organic matter and chemically combined water	2.28	3.90
The soluble part consists of—		
Sodium sulphate (Glauber's salt)	.29	.05
Potassium sulphate	.77	.13
Sodium chloride (common salt)	.68	.12
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	4.71	.81
Calcium sulphate (gypsum)	.25	.04
Silica	3.51	.60

Sanitary Analysis.

Total residue	13.73	grains per gallon.
Chlorine	.41	grains per gallon.
Free ammonia	.026	parts per million.
Albuminoid ammonia	.04	parts per million.
Oxygen consumed	.40	parts per million.

For domestic use this water is entirely unexceptionable, not only from the small amount of salts present, and the character of the salts, but from its freedom from sewage matter, as shown in the sanitary analysis.

For irrigation it is also very acceptable, though there is little more carbonate of soda present than is desirable if the land is clayey; upon well-drained loams and sandy soils it would produce very little injury.

The amount of potash present is too small to make much impression as a fertilizer. In each cubic foot of water there would be 5.75 grains of potassium sulphate, and if flowed over the land to a depth of one inch would give to the soil 2½ pounds per acre.

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III. ANALYSES OF ROCKS, CLAYS, MARLS, ETC.

Rock fragments, from A. McLean, Lompoc, Santa Barbara. Supposed to contain gypsum, but an examination showed that mineral to be entirely absent.

Mineral, from J. N. Bowhay, Traver. A soft white material, supposed to be gypsum, but which proved to be only a very good calcareous marl.

Mineral, from San Luis Obispo County; sent by Geo. Edgar, San José. A white, soft material, which is said to occur in great quantity in the mountains of San Luis Obispo County. It is quite salty in taste and proves to be *glauberite*, or sulphate of soda, with a little lime and magnesia.

Mineral; sent by C. T. Brown, Porterville, Tulare County. Proved to be only a quartz rock.

Minerals, from Jas. Mills, Riverside; supposed to be gypseous. One of these specimens is limestone, the other is a crystal of calc-spar.

Rocks, from A. C. Loveland, Moosa, San Diego County; four specimens sent for identification. No. 1 is a hydrated silicate of lime. No. 2, a vein rock, perhaps gold-bearing in some portions. No. 3, a black eruptive rock with a white zeolite mineral. No. 4 is an impure graphite.

Mineral; sent by Miss A. Osburn, of Riverside, for identification. It is galena or sulphuret of lead.

Limestone; sent by B. W. Handy, Riverside, to be examined for phosphoric acid. There proved to be but a small amount present, but no more than is to be found ordinarily in rocks.

Limestone, from Chas. E. Maud, Riverside. This was supposed to be a phosphoric rock, but proved to have no more phosphoric acid than is contained in ordinary limestones.

Mineral, from Shasta County; sent by B. Marks. Under the microscope proves to be only volcanic ash.

Rocks and clays (five samples), from Dr. E. B. Perrin, San Francisco. They were supposed to be phosphatic rocks, but an examination showed the presence of but a small amount of phosphoric acid in each sample.

Minerals, from P. F. Kellam, Perris, Cal., to be examined for gypsum. The specimens are respectively marl and a crystal of calcite (carbonate of lime). No gypsum was found in the marl.

Mineral, from D. W. Osborne, Winchester. This proved to be small concretions of sulphate of alumina, and of no value.

Deposit in the mountains of Ventura County; sent by Byron H. Wiley, Fillmore. An examination showed this to be an earth slightly calcareous and dark from decayed vegetation.

Minerals, from Will Dawkins, Yager, Humboldt County. One of these is magnetic iron, with a little copper oxide; the other red oxide of iron, or "gossan."

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"*Fertilizing material,*" from G. B. Pratt, of Alosta, Los Angeles County; two samples. One of these proved to be carbonate of lime, the other a shaly clay. Neither of these are of use as fertilizers on the soils of the region.

Deposit; sent by Mr. Hammond, of Lancaster. "Has it any commercial value?" The material proved to be only common and Glauber's salts, and of no value.

Rock, from B. W. Handy, of Riverside; to be examined for phosphoric acid. The sample is chiefly carbonate of lime, and contains very little phosphoric acid.

Rock, from Geo. Schwinn, of Huron, Cal.; to be examined for gypsum. The specimen is decomposed serpentine, very smooth and unctuous to the finger; no gypsum.

Earth, from J. F. Moore, of Santa Barbara; to be examined for phosphoric acid. The sample is black and sandy, with very little phosphoric acid.

Mineral, from David Etting, of Edgewood, Siskiyou County. "It was cut out of a rock-bed. On becoming dry and exposed to the air, it pulverizes very easily." The sample is in a finely pulverized condition; does not become plastic with water; contains a little phosphoric acid. Under the microscope it proves to be chiefly volcanic ash.

Ferruginized wood; sent by R. Wegener, of Livermore. It has the following composition:

Moisture	17.06 per cent.
Organic matter	43.34 per cent.
Silica	6.36 per cent.
Iron, alumina, lime, and magnesia	33.24 per cent.
	100.00 per cent.

Rock, from San Luis Obispo; sent by R. E. Doyle. A soft white lime-rock, with 24.61 per cent of residue, insoluble in acid. The remaining 75.39 per cent is chiefly carbonate of lime.

Salt sediment, taken from a gulch just below one of the Tuscan Springs, 8 miles east of Red Bluff. The sediment contains a very large amount of chloride of soda (common salt) and some sulphate of soda and magnesia.

Marl; sent by Val. Garner, of Hollister. An analysis showed it to be composed of—

Insoluble matter (sand, etc.)	40.06 per cent.
Iron and alumina	4.10 per cent.
Carbonate of magnesia	2.21 per cent.
Phosphoric acid	.12 per cent.
Carbonate of lime, etc.	53.51 per cent.
	100.00 per cent.

Marlstone; sent by T. F. Ellsworth, of Pasadena. A soft, yellowish-white rock, with but little insoluble matter, including some sand. There is only a trace of phosphoric acid, and but very little magnesia. It would probably make a fair mortar, but is hardly fit for plastering, being too yellowish and with blackish sand specks.

Limestone; sent by W. A. Sickler, of Julian, San Diego County. The rock is quite gypseous in character, as shown in the following result of an examination:

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Insoluble matter	10.29 per cent.
Gypsum	19.16 per cent.
Magnesia carbonate	9.62 per cent.
Lime carbonate, etc.	60.93 per cent.
	100.00 per cent.

Limestone; sent by J. G. Curtis, of Pentz, Butte County. The rock contains 10 per cent of insoluble matter, the rest being carbonate of lime chiefly.

Limestones, from the Old Mission Valley, San Diego County; sent by Nicholas Treosti, Los Angeles, to be examined for cement quality.

	Specimen No. 1.	Specimen No. 2.
Sand	11.70	5.02
Fine matter	14.50	6.63
Iron and alumina	4.00	2.00
Carbonate of magnesia	.50	.40
Carbonate of lime	69.30	85.95
Sulphate of lime	Trace.	Trace.
Totals	100.00	100.00

These are simply impure limestones, with no qualifications for making cement other than that, if mixed in proper proportions with the proper kind of clay in the manner employed in making Portland cement, it can be done.

Limestone, from San Jacinto, San Diego County; sent by T. R. Haas. Its composition is as follows:

Carbonate of lime	72.40 per cent.
Carbonate of magnesia	Trace.
Phosphate of lime	.10 per cent.
Sand, etc.	27.50 per cent.
Potash	Trace.
	100.00 per cent.

The sample does not contain enough potash and phosphates to make it of any value as a fertilizer. Then, too, the soils of California are well supplied with lime as a rule.

Marble (two samples), from Amador County; sent by the Carrara Marble Company, San Francisco, for the purpose of ascertaining whether or not the marble contains any substances which would prevent its use for monuments or building stone.

The "black" sample contains 25 per cent of insoluble matter, consisting in part of iron pyrites and garnet crystals.

The "white" sample contains 4 per cent of insoluble matter, which, under the microscope, showed crystals of iron pyrites.

These two varieties could not well be used in positions where the surfaces would be exposed, as the iron pyrites at or just beneath the surface would weather and greatly injure the appearance of the rock.

Clay, from Carbondale, Amador County; sent by W. R. Felter, of San Francisco; five samples of whitish potter's clay, to be tested as to their adaptability for fire brick. They are all plastic with water. Before the blowpipe they are slightly fusible at a very high temperature, and hence while brick made from them may be used in ordinary furnaces, they will not stand the higher heat of iron furnaces.

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Rock fragment, from W. B. Hosmer, of Santa Maria; sent for identification. A white material easily crushed into sharp grains, which under the microscope appear to be of volcanic ash or pumice.

Rock and earth, from W. P. Yanby, of Bishop; the rock to be examined for tin ore. The rock is an iron ore with not a trace of tin. The earth is saline in character, with sulphate of soda and common salt.

Clay, supposed to contain corundum; sent by Chas. A. Raber, of South Riverside. It is an arkose material, made up of fragments of feldspar, quartz, mica, chlorite, and other minerals with clay.

Greenish clay, from T. A. Magee, of San Bernardino; to be examined for gypsum. The sample is only a clay colored green by ferrous oxide. It contains no gypsum.

Earth; sent by Messrs. Long Bros., of Fresno; to be examined for gypsum. A whitish earth, containing neither gypsum nor infusoria. It has the character of volcanic ash.

Ashes, from H. W. O'Melveny, of Los Angeles. The ashes had been produced by burning manure and wood, in the proportion of three of the former to one of the latter, and it was desired to know how this had affected the material as a fertilizer on orange trees. However valuable the material might be intrinsically, it is practically spoiled by too much heat in burning. Nearly three fourths of it consists of fused ash, in the form of glass beads, and worth nothing for fertilizing purposes until treated with sulphuric acid. Of the remaining one fourth a good proportion is merely fine sand.

Paris green; four samples sent for examination. Samples Nos. 1 and 2, sent by James Ward, of San Francisco; sample No. 3, sent by Mr. Treat, of Contra Costa; sample No. 5, sent by A. P. Crane, San Lorenzo.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Hygroscopic moisture	1.02	.58	.94	2.48	.....
Arsenious acid	54.07	55.73	38.21	54.38	56.18
Copper oxide	33.46	32.54	30.69	34.19	.....
Acetic acid	11.45	11.15	30.15	8.95	.....
	100.00	100.00	100.00	100.00	.....

Yellow ochre, from Hollister; sent by N. C. Briggs. A light yellow powder, somewhat intermixed with granular matter. It is an ochre susceptible of good uses as a paint.

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IV. ALKALI.

RECLAMATION TEST WITH GYPSUM AT THE EXPERIMENT STATION NEAR TULARE.

By R. H. Loughridge.

The question of the reclamation of alkali lands of the State has been one of great importance and has received much attention from the Station. The application of gypsum as recommended by Professor Hilgard some time ago, seems to be the true remedy for the evil, though a rather expensive one at the present prices of that mineral.

That gypsum will act upon the alkali (carbonate of soda) and change it to the far less hurtful sulphate of soda (Glauber's salt) is clearly shown, in small quantities. But in the field and on extensive tracts the effect of application is slowly apparent, because of the many conditions that surround the experiment, such as imperfect drainage, lack of moisture, etc.

The San Joaquin Station, near Tulare, has been made the center of experiments with gypsum, because of the presence of a spot of land strongly charged with alkali; the crystals of carbonate of soda glisten upon the surface, and the black humus spots so characteristic of alkali are very prominent. Two beds of hardpan have been formed by the alkali instead of the usual one bed, and altogether the spot selected is one in which the effect of gypsum can be fully tested. The experiments, or treatment, were carried on under the direct supervision of the Foreman of the Station and the Inspector of Stations. From time to time samples of the water from leaching the soil after treatment were sent to the laboratory to be examined. Samples of the soil from the treated and the untreated plots were taken, respectively, at the surface, at 3 feet, and at 6 feet below the surface, and sent also for examination as to the respective contents of alkali. The results are found below. The character of the land and details of treatment are thus given by Mr. Shinn, the Inspector of Stations:

CHARACTER OF THE LAND.

The Tulare Station has frequently been referred to as affording an excellent opportunity to experiment with alkali soils. A place was chosen in the northeastern corner of the tract in 1890, where one fourth of an acre might be operated upon.

The general nature of the soil on the tract, a part of which has been used for the experiment described, is fairly typical of the alkali region. The surface shows crystals of alkali; no vegetation; wheat stalks would be destroyed, and even sorghum would fail on the soil. It is difficult to name a useful crop that would thrive there. Sinking a shaft to the gravel and water-level, some 9 or 10 feet below the surface, the alkali hardpan is found to lie mainly in two streaks or layers in the upper 2

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feet. Beneath is hard, yellow clay, then a whitish clay, softer as it descends, more moist, and mixed with sand. The sand increases toward the water-level. The fact that the difficulty to be overcome is mainly near the surface, is the best feature of the alkali problem. It lies within reach, 90 per cent of the alkali in a 10-foot column of such soil as that just described being within easy reach of a subsoil plow.

The entire plot chosen for operations covers about one acre. A portion is occupied by one of the curious basins, or "sinks," common in the region; an irregular, blind channel, beginning and ending with abruptness, and marking the course of an old stream. It was determined to sink a drainage pit, or sump, through the surface soil to the gravel pit underneath. A plot of one fourth of an acre was so marked out as to be convenient for drainage into this sump. The pit was dug and lined with rough redwood to prevent caving; three redwood underdrains were carried across the plot and made to discharge into it. Two 8-inch redwood boards were nailed together to make a drain, shaped like an inverted V, and put about 3 feet deep, sloping toward the sump. While this preliminary work was well done, it was also done as cheaply as possible; rough lumber and ordinary farm-hand assistance.

The plan proposed was, in brief, this: To make a slight embankment around the experiment plot, to sow the plot with gypsum or land plaster, and cover it with water, which should gradually pass down into the drains and carry off much of the alkali into the general drainage system of the country.

The plot was first plowed in 1890, and received no less than five plowings. It was exceedingly difficult to work, as all who have ever attempted to handle the strongest of alkali soil know by dear-bought experience. In the spring of 1891 it was plowed again. Such alkali soil, after a rain, runs together and becomes almost as compact as if never broken. No plaster was used during these successive plowings, the purpose being to see the effect of deep culture alone.

October 16th the Foreman, Julius Forrer, wrote: "Shall begin with the alkali tract as soon as the pump pipes to carry water are fixed, which will be this week." The pump is near the stables, is operated by a two horse-power, and fills a 4-inch pipe with an almost constant stream, the distance the water is lifted being only 12 or 15 feet. Joints of light pipe are used to carry it across the grounds to the desired point.

October 26th the Foreman wrote: "Have fairly commenced operations on the alkali corner. Used 500 pounds of land plaster. The trenches work well, also the sump. I send a bottle of the first water that passed through the drains. After I have flooded the whole piece of ground, and it has settled, I shall plow again and repeat the flooding."

October 29th he reported that the first flooding was complete. The sump filled to the top, and then lowered rapidly. He was written that the drainage was too rapid, so he plugged the drains, for a few days at a time, when it seemed advisable to check the flow.

November 4th he wrote: "Had the ground in some places partly spaded, partly plowed." (It was so hard that the water would not soak through.) "We then pumped water on to it. I have no doubt that we will have to repeat the same many times, as the layer of alkali is at a depth of from 1 to 2 feet from the surface, and it forms a heavy hard-

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pan that is as hard as a rock and keeps the water near the surface. If the expense would not be too great, it would be advisable to break the ground much deeper."

November 6th the Foreman wrote: "It will require time. The soil where the alkali is bad is as hard as an asphaltum floor. When the hardpan, 1 foot or so thick, is broken, the ground is soft below. As soon as the alkali land begins to dry, it melts together."

November 6th the Foreman spaded hard parts of the plot, and broke the hardpan with a pick. He said that it was "as hard as iron." A two-horse team was unable to plow it, for the plow broke the first time the work was undertaken. The pick was therefore used, and the alkali hardpan broken to the depth of 14 inches. More water was then pumped on the plot. The Foreman adds: "The breaking up is necessary. I took some lumps (of the hardest alkali) and put them in water for twenty-four hours, and they did not melt. Similar lumps, well sprinkled with plaster, 'slacked' to pieces in a few hours. *The plaster is essential.*"

This work with the plot was kept up until the close of the year, and, as will be illustrated by a table, the injurious salts were largely diminished.

To summarize briefly the treatment, it was as follows: November 2d, land was plowed and 500 pounds of land plaster applied, or at the rate of one ton to the acre. The water pumped on it was about 50,000 gallons. The drains were plugged for three or four days. November 9th, the "crust" was broken and more water applied; no plaster. November 16th, more water, about 25,000 gallons. The water sank along the line of the drains and ran out immediately. Drains were stopped, and the hardpan again broken up. November 24th, more plaster (150 pounds) put on upper half of plot; none on lower half. For subsequent week, more water, and worst places broken up. November 27th, 150 pounds of plaster used on all the bad spots of the tract, a shovelful here and there. December 4th, 100 pounds of plaster used in the same way. This makes a total of 900 pounds on the quarter acre, or at the rate of 3,600 pounds to the acre. It seems a large amount; at the present price of plaster the job was rather an expensive one. But plaster can be obtained in the foothills, and supplied to the San Joaquin at a price which will justify the use of 2 or even 3 tons per acre, provided that it accomplishes the desired results.

In reclaiming a tract of "black alkali," the first thing to consider is the saving of the best qualities of the soil; it will not do to destroy or leach out the humus. What is wanted is to neutralize the salts, and retain all the plant-food possible. The way that plaster operates when properly used, was well illustrated in the experiment plot in December. Over the wet surface were many piles of dark earth that seemed like fresh gopher mounds, or mole-hills newly broken—they marked the points where masses of alkaline "crust" had been shattered by the plaster sprinkled over. It would have been better to have used more plaster at the beginning of the experiment, and to have distributed it through the soil more evenly and as deep as possible. Plaster applied after each plowing and before each watering, to the total of 1,000 pounds on the quarter acre, would probably have left the soil in better condition than the way it was used.

The next plot to be experimented with will offer a chance for such changes in method. On this plot it is proposed to break up the clay

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with small charges of powder, and avoid the expense of drains, except a short one to obtain water for analysis. Operations have begun on this plot. Grain will be planted on the reclaimed plot the coming spring, and the results given in the next report. (C. H. S.)

EXAMINATION OF THE PERCOLATING WATER.

The water taken from the drainage pipe from time to time, after the treatment with gypsum and flooding with water, should represent the changes that take place in the soil. The samples were therefore carefully analyzed, with the results shown in the following table:

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Waters from Drainage Pipe of Alkali Land After Treatment with Gypsum.

	Taken October 26th.		Taken November 4th.		Taken November 16th.		Taken November 27th.		Taken December 4th.	
	Grains per Gallon	Percentage of Residue	Grains per Gallon	Percentage of Residue	Grains per Gallon	Percentage of Residue	Grains per Gallon	Percentage of Residue	Grains per Gallon	Percentage of Residue
Total residue by evaporation	115.53	100.0	145.13	100.0	189.83	100.0	103.27	100.0	148.36	100.0
Soluble in water after evaporation	45.15	39.1	100.52	69.3	148.83	78.5	86.46	83.9	122.43	82.6
Insoluble in water after evaporation	61.97	53.6	20.25	13.9	20.74	10.9	10.52	10.2	18.93	12.7
Organic matter and chemically combined water	8.41	7.3	24.36	16.8	20.26	10.6	6.19	5.9	7.00	4.7
The soluble part consists of—										
Sodium and potassium sulphates (Glauber's salt, etc.)	5.99	5.1	46.14	31.8	70.40	37.1	34.74	33.7	79.05	53.3
Sodium chloride (common salt)	21.82	18.9	25.92	17.9	45.69	24.1	29.62	28.8	27.28	18.4
Sodium carbonate (sal soda, "black alkali")	17.34	15.1	22.90	15.8	19.06	10.1	17.34	16.8	11.14	7.5
Sodium nitrate			5.56	3.8	13.68	7.2	4.74	4.6	4.96	3.4
The insoluble part consists of—										
Calcium and magnesium carbonates Calcium sulphate (gypsum), silica	61.97	53.6	20.25	13.9	20.74	10.9	10.52	10.2	18.93	12.7

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The sample whose analysis appears in the first two columns was taken from the first of the water that seeped through the alkali soil, and probably before the gypsum had time to produce much effect. It will be seen that of the entire solid residue of 115 grains per gallon, 15 per cent was of the carbonate of soda, or "black alkali," while but 5 per cent was of the Glauber's salt; and that more than one half of the residue was of the carbonates of calcium and magnesium. It is plain that the gypsum had hardly begun to act, and that the larger part of the salts were locked up in the thick lumps of hardpan, which, although broken up, were almost impervious to water.

After the moist gypsum had acted upon the alkali salts and the hardpan for nine days, another flooding of the soil was made, and a sample of the water as it came through was taken. Its analysis, given in the third and fourth columns, is extremely instructive in illustrating very forcibly the power of gypsum in disintegrating hardpan, and at the same time in acting upon the carbonate of soda and converting it into the sulphate, or Glauber's salt. The breaking up of the hardpan naturally released much of the soluble contents, and we find a larger total residue in the water, an increase of nearly 30 grains per gallon. The residue contains the same percentage of "black alkali" as at first, but there is an increase of nearly eight times the amount of Glauber's salt, and the percentage composition has risen from 6 to 31.8. This increase very nearly represents the amount of carbonate of soda that has been converted into the sulphate by the action of gypsum, or in other words, had there been no gypsum applied to the soil, and the hardpan pulverized so that water could reach the alkali, the leaching would have shown nearly 62 grains of carbonate of soda per gallon, instead of 22.9. The amount of carbonate of lime, etc., had fallen off to but 14 per cent of the residue.

The gypsum was then allowed to act for twelve days, more water added, and another sample taken. The analysis shows that the solid residue is constantly increasing, and has reached nealy 190 grains per gallon. The carbonate of soda has decreased from 23 to 19 grains, while on the other hand the Glauber's salt has increased from 46 to 70 grains. Common salt has also increased largely.

The results are, however, more instructive when considered with regard to the percentage composition of the residues of the two samples, for we find that while the carbonate of soda has decreased through 5.7 per cent, or from 15.8 to 10.1 per cent, the Glauber's salt has increased through 5.3 per cent, or from 31.8 to 37.1 per cent—a nearly equal ratio of decrease and increase. The carbonate of lime, etc., has also fallen off.

A few days later more gypsum was added to the bad places, and on November 27th another sample of water was taken. The analysis shows a great decrease in total residue per gallon, but there is exactly the same amount of carbonate of soda per gallon as at the very first (17.34 grains). It must be remembered, however, that the loosening up of the hardpan by the gypsum had released a much larger amount, so that the present sample shows that the soil as a whole had been freed from alkali and reduced to the condition of the original soil *outside of the hardpan.* On comparing this analysis with that of water taken when the alkali in the hardpan had been released, it is seen that there

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is still a gradual decrease of the carbonate of soda, though its percentage of the residue per gallon is larger.

The final application of gypsum was made on December 4th, and after allowing it to act for awhile, a sample of water was again taken. Its examination shows that not only has the solid contents per gallon increased, but that this increase was chiefly in the sulphates of soda, etc., formed by the action of the gypsum on carbonate of soda; that the carbonate of soda had fallen off very greatly and formed but 7.5 per cent of the residue, or 11.14 grains per gallon.

Summary of Results.—Glancing at the results as a whole, we obtain the following facts: The *total residue* increased from 115 to 189 grains per gallon by the disintegration of the hardpan, and remained practically at about the same amount at the last as at the first. More than half of this comprised the insoluble lime and magnesium carbonates at first, but these decreased to less than one eighth at the last, while there was an increase of the soluble salts from 39 to about 83 per cent.

The chief interest lies, however, in the *part soluble* in water, where we find on the one hand the carbonate of soda, or "black alkali," and on the other the sulphates of soda, etc., into which the carbonate is converted by the action of gypsum.

On October 26th, when the experiment began, there were but 6 grains of the sulphate of soda per gallon present in the seepage water, or 5.1 per cent of the whole residue, while there were 17.3 grains of the carbonate, or 15.1 per cent. The disintegration of the hardpan by the gypsum, already alluded to, doubtless released a very large percentage of the carbonate, but in the nine days much of that had been converted into the sulphate, as shown in the sample of November 9th.

The experiment was closed for the season on December 4th, and an examination of the water then showed that the carbonate of soda had fallen from the extreme of 22.9, on November 11th, to 11.1 grains per gallon, and from 15.8 to 7.5 per cent of the residue; or in each case a little more than 50 per cent. On the other hand, the sulphate of soda, or result of the change, had increased from 5.99 to 79.05 grains per gallon, or from 5.1 to 53.3 per cent of the residue. *Thus fully one half, or 50 per cent, of the carbonate of soda originally present in the drainage water has been removed.*

The percentage of sodium chloride is about the same from first to last, though it had increased largely in two of the intermediate leachings.

The nitrate of soda also remains about the same at the last as at first, but in the sample of November 16th the percentage had nearly doubled. It is certain that though the carbonate of soda ("black alkali") had been reduced one half, there was still enough present to act strongly on the organic matters, humus, and nitrates of the soil, and carry them off in solution with the drainage waters.

EXAMINATION OF THE SOILS.

The samples of soil taken for examination were from two places near the middle of the large alkali plot, half of which is being treated. One series was taken from the side of a shaft sunk between the drains, in the half that is undergoing treatment, while the other series was taken from a similar shaft, about 20 feet distant, in untreated soil, similar in every respect, as previous tests, several years ago, had sufficiently demon-

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strated. In taking each sample, the cubic foot desired was cut out, and pulverized in a box, mixed, and a sample sack filled from the mixture. (C. H. S.)

The following analyses give the percentages of alkali present in the soil before and after treatment with gypsum:

Alkali Soils, Natural and After Treatment with Gypsum.

Soluble Salts in 100 parts of soil.	First Foot.		Third Foot.		Sixth Foot.		Average.		
	Natural.....	Treated.....	Natural.....	Treated.....	Natural.....	Treated.....	Natural.....	Treated.....	Diminution, Per Cent...
Sodium and potassium sulphates (Glauber's salt, etc.).....	0.151	0.005	.....	0.012	0.002	0.011	0.051	0.009	17.6
Sodium chloride (common salt).....	.084	.009	0.56	.005	.001	.007	.047	.007	14.9
Sodium carbonate ("black alkali").....	.094	.051	.096	.010	.005	.008	.065	.023	35.4
Sodium nitrate.....	.008	.006	.....	.....	.....	.....	.....	.....	.....
Totals.....	.337	.071	.152	.027	.008	.026	.163	.039	23.9

The results of the treatment with gypsum are plainly shown in the above tables, and, altogether, are very encouraging, for they prove that, by the judicious use of gypsum and water, the "black alkali," or carbonate of soda, can be changed to the sulphate, or what is known as white alkali; and this, by proper drainage, removed from the soil.

For the *first foot*, a comparison of the columns giving the analyses of untreated and treated soils shows a very great diminution (four fifths) in all of the salts after treatment with gypsum and flooding with water. This is greatest in the sulphates which have passed into solution and been leached out; next, in the chloride of sodium, or common salt, which also has been leached out; while the carbonate of soda has also been reduced to nearly one half, though to a far less extent than the other salts. Its relative proportion to the remaining salts, as shown in the second table, is larger than in the untreated soil. The nitrate of soda is so small in amount, both before and after treatment, that it is not worthy of mention.

In the *third foot*, we find a reduction of 82 per cent in the total salts, and in the carbonate of soda of about 90 per cent. This latter is much greater than in the first foot, and perhaps can be accounted for not only in the reduction to sulphate by the action of the gypsum in solution, but to a transfer of a part to the upper surface of the soil by the drying out and consequent rise in the alkali holding moisture, and thus increasing the surface alkali over and above what was left after the action of gypsum. The sodium chloride has also been reduced to one tenth of what it was in the original third foot.

In the *sixth foot*, the gypsum does not seem to have penetrated, for there is not only a larger amount of other salts present, but the carbonate of soda has increased somewhat over that in the untreated soil. This result is doubtless due to the leaching effect of the water, which has carried all of the salts down to that depth and left behind this residue. In the original soil, the leaching to lower depths by rains was doubtless prevented by the impervious beds of hardpan; the action of the gypsum

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was to disintegrate these beds and to render the soil porous and offering no resistance to percolating waters. The effect of gypsum upon a lump of alkali hardpan is very similar to that of water upon unslaked lime, a rapid falling to pieces and crumbling, but without the heat of the latter.

As *a summary* of results for the whole soil to a depth of 6 feet, we find that the treatment has reduced the entire salts to about 24 per cent of what was in the natural soil; that the leaching and drainage have carried off about 83 per cent of the sulphates of soda and potash, and about 85 per cent of the chloride of soda of the natural soil. We also find that *the gypsum and leaching with water have changed to sulphate and carried off about 65 per cent of the carbonate of soda.* A glance at the table giving the composition of the water leached through the soil after treatment shows conclusively that the diminution of the carbonate was due to a change to sulphate, and not entirely to the mere leaching out, for the amount of sulphates per gallon in the water is far in excess of what would have come from the untreated soil. The result as shown in the table above for the average, shows that the carbonate is in excess of the sulphates in the natural soil, and this would have occurred had no gypsum been applied.

Alkali Accumulates Near the Surface.—The examination of the soil specimens obtained at different depths confirms what has already been said, viz.: That the capillary movement of the alkali ground water toward the surface of the soil, and its evaporation there, tends to the accumulation of the alkali near the surface, while in the depths below there is comparatively a small amount. It also indicates the danger of using irrigation waters that contain even small amounts of the alkali, for these soon are concentrated as above seen. In both soils is this surface accumulation seen. In that which has not been treated with gypsum, the entire three samples taken at 1, 3, and 6 feet, respectively, show a total of 0.489 per cent of soluble salts, of which 0.189 per cent was carbonate of soda (black alkali), or about 40 per cent of the whole salts (sulphates, carbonates, and chlorides). The first foot shows a total of 0.339 per cent of soluble salts, 28 per cent of which is of the carbonate of soda. In the third foot the soluble salts have diminished to 0.152 per cent, and the carbonate of soda, while about the same in amount, is 63 per cent of the total salts, only a very small amount of the sulphates being found in the sample examined. In the sixth foot the total salts have still further fallen off to 0.008, or almost nothing, the carbonate of soda also being extremely low. Altogether, the carbonate of soda exists in about the same amounts to a depth of at least 3 feet, and comprises about 96 per cent of the total "black alkali," the other 3 feet having but 4 per cent.

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COMPOSITION OF THE ALKALI.

The following table presents the composition of the alkali itself, without reference to the amount in the soil:

Percentage Composition of the Alkali Before and After Treatment with Gypsum and Flooding

Soluble Salts.	First Foot.		Third Foot.		Sixth Foot.		Average.	
	Natural.	Treated.	Natural.	Treated.	Natural.	Treated.	Natural.	Treated.
Sodium and potassium sulphates (Glauber's salt, etc.)	44.8	7.0	----	44.4	25.0	42.3	31.3	23.0
Sodium chloride (common salt)	24.7	12.6	36.8	18.9	12.5	26.9	28.2	17.9
Sodium carbonate (sal soda or "black alkali")	27.9	70.2	63.2	36.7	62.5	30.8	40.5	59.
Sodium nitrate	2.6	10.2	--------	--------	--------	--------	--------	--------
Totals	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The alkali in the first foot of the natural soil is quite similar in composition to that of the valley at large. In the third and sixth foot samples the proportion of carbonate soda was far in excess, and in the average of all the samples the proportion was rather larger than usual. In that portion treated with gypsum, the breaking up of the hardpan and leaching have removed the greater part of the sulphates, leaving the carbonates in excess.

CROP TESTS.

Mr. Shinn, the Inspector of Stations, makes the following report:

"It is very well known that upon soils severely charged with black alkali, it is impossible for culture plants to grow and thrive; the spots being often bare of any vegetation. At the end of the treatment with gypsum, as described above, seeds of a number of plants were sown, with the following results:

"Japanese buckwheat grew very well until it attained a height of about a foot, when the plants burned and wilted in the sun. It does poorly in this district at the best.

"Barley, planted late, in the center of the spot, did fairly well, a portion making heads, and all the stalks being at least 18 inches high.

"Six varieties of sorghum all did very well, everything considered. Some made stalks 6 feet high, and if the entire plot had been sown to sorghum, it would have been profitable.

"Sugar-beets made a very poor showing.

"It is evident from the above tests that a percentage of 'black alkali' even as low as half of one tenth (0.05) is too much for the full growth and maturity of our ordinary field crops; and that one tenth of one per cent is very destructive to the young plant, if not to the seed itself. After the plant becomes rooted it will stand more alkali. The mechanical handling of the soil is very important. It might pay to drill sand over the seeds, so as to prevent the soil from hardening before they sprout."

The following extract, showing the results of gypsum on alkali land in other localities, is taken from the "Weekly Colusa Sun" of August

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13, 1892: "Several people have tried gypsum in Colusa County in the past year, and have been more than pleased in each case. P. V. Berkey says he has reduced a large spot of alkali that he has known for over twenty years to be barren, and he, after one application, raised three tons of hay to the acre. J. B. DeJarnatt tried it on some vines he had on an alkali spot, and it worked like a charm. Frank Willis tried it around some peach trees, and it brought them out in a wonderful manner. In fact, every trial has been a success. Such work as Professor Hilgard has been doing is worth to the State the whole cost of the University."

ANALYSES OF ALKALI.

Alkali, from Dos Palos; sent by B. Marks. It is composed of sulphates of soda, lime, and magnesia, and a little common salt, and is therefore of the "white alkali" class.

Alkali; sent by A. C. Smith, of Oleander. It contains no carbonate of soda, and is of the "white" variety.

Alkali, from Brown's place, near Dos Palos. A white surface deposit, which proves to be only sulphate of soda, or "white alkali."

Soluble alkali, in soil of West Lake Park, Los Angeles; sent by P. A. Howard, Assistant Treasurer of Park Commission. The air-dried soil contains 7.5 per cent of soluble matter, consisting mainly of common salt with considerable calcium chloride and small amounts of magnesium chloride and sulphates and carbonates of the alkalies.

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V. FRUIT AND VEGETABLE PRODUCTS.

INVESTIGATION OF CALIFORNIA PRUNES, APRICOTS, PEACHES, ORANGES, LEMONS, AND OLIVES.

The work here discussed was entered upon two years ago, in response to the constant demand of growers of citrus fruits for information as to the most appropriate fertilizers to be used by them.

In the last annual report the results of the analysis of twenty-seven samples of oranges and lemons were given.

During the past year these investigations have not only been continued for citrus fruits, but have been extended so as to embrace prunes, peaches, and apricots; and the results are given below.

The subjects discussed are summarily set forth in the following quotation from Bulletin 93, of this department:

"The purpose of this work is to show comprehensively the proximate and ash composition of the leading varieties of fruits as grown in the principal fruit regions; and inferentially, the influence exercised upon them by the prominent conditions of soil, climate, fertilizers, etc. The physical data (proportion of pits to flesh, etc.) are of interest from a commercial standpoint, as showing what is being purchased as to available and waste material, etc.

"The consumer, though usually considering fruit as a luxury, would derive much valuable knowledge from studying the fruits in their relative values as foods. The nourishing portions, shown especially by the nitrogenous and saccharine contents, vary greatly with the variety and conditions of growth. It is not, then, a matter of indifference to the consumer what fruit he uses, but an important question of domestic economy.

"The ash ingredients, together with the nitrogen contents of the standard varieties, are of high interest in connection with the vital question of soil exhaustion and fertilization. The soil ingredients extracted by an ordinary crop are a serious drain upon the supporting soil, and the lines of heaviest draft can only become known by the actual determination of the constituents withdrawn."

It will be observed that the majority of the fruits here reported are from the Santa Clara Valley, from which they were most readily obtained. It is of course intended to extend this work, hereafter, to *all* the fruits grown in California; notably, during the coming season, to all obtainable varieties of figs from the different regions; also, a more numerous representation of apricots, prunes, and other plums. It is well known that these fruits differ materially in their qualities, *e. g.*, as between North and South California, and between the valley and the foothills. These investigations will not only aid in determining the best uses to which these several fruits may be put, but also in what direction and to what extent the soil ingredients taken from the soil by them require replacement. Raisins and table grapes, as well as cherries, pears, etc., will come in their turn in succeeding years. Meanwhile, producers interested in these questions are invited to communicate with the Station in regard to the examination of their fruits.

In the work here presented, as in that previously done on citrus fruits (Bulletin 93), Assistant Colby has been very efficiently assisted by Mr. Hubert P. Dyer, a graduate student in this department. (E. W. Hilgard, Berkeley, May 31, 1892.)

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PRUNES, APRICOTS, AND PEACHES.

By GEORGE E. COLBY.

(*University Experiment Station Bulletin No. 97.*)

The following analyses of some California prunes and apricots of the crop of 1891, and discussion of results, are the preliminary steps toward carrying out the purposes explained in the introduction:

DESCRIPTION OF PRUNES.

No. 1, Prune d'Agen, Mountain View; S. F. Leib, grower; sample received September 28, 1891. Usual size, but more rounded than the other samples of the same variety; quite ripe; soft and very sweet.

No. 2, Prune d'Agen, Niles; Wm. Mortimer, grower; sample received August 26, 1891. Condition good, fully ripe and very sweet.

Nos. 3 to 12, San José; John Rock, grower. All these samples, except No. 12, were received on September 8, 1891; No. 12 (St. Catherine) came October 3, 1891, and represents a fully ripe sample; No. 11 (St. Catherine) was rather green. Condition excellent for all these samples; No. 3 (French), No. 7 (Hungarian), and No. 10 (Datte d'Hongrie) being soft, rather juicy, and sweet; No. 7 tasted quite tart; No. 4 (Wangenheim), No. 5 (Robe de Sergent), No. 6 (Fallenberg), No. 8 (Bulgarian), and No. 9 (German) were firm-fleshed and much less sweet than the other members of the series.

DESCRIPTION OF APRICOTS.

Nos. 13 to 18, Niles; James Shinn, grower; samples received during August, 1891. No. 13 (Hemskirk), August 3, 1891, was hard and unripe. The other varieties, No. 14 (Hemskirk), No. 15 (Blenheim), No. 16 (Royal), No. 17 (Peach), and No. 18 (Moorpark), were in good condition, fully ripe and quite sweet.

No. 19, Pringle (?), Tulare; grown by B. F. Moore. This sample was received June 30, 1891, and has already been reported (Agr. Expt. Stat. Rept., 1890, page 115).

DESCRIPTION OF PEACHES.

No. 20, Orange Cling, and No. 21, Lemon Cling; samples received September 25, 1891, from L. C. McAfee, San Francisco. Condition only fair, as the fruit had been picked for some time. No. 20 was grown by H. M. Alexander, Anderson, Shasta County; No. 21 by General Bidwell, Chico.

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The accompanying table shows the results of the analytical work for the season of 1891; the first subdivision (A) gives the physical and general proximate analyses; the second (B) the results of the analyses of the ash. Lack of time prevented us from making as extended a work as was desirable upon the ash—that which has been accomplished indicates at least the general character of the ash composition.

The chief points shown by the table will be better understood by a brief discussion as to similarity or difference.

PROPORTION OF PITS TO FLESH.

Prunes.—The range in the percentages of pits is from 3.7, in Hungarian (No. 7) to 7.5 in Robe de Sergent (No. 5); 5.5 per cent representing the general average, thus leaving about seventeen times as much flesh as pits. Thus, the consumer finds that on the whole the prunes possess but little advantage over each other in regard to the proportion of pits to flesh.

Apricots.—Leaving out of consideration the Pringle (No. 19), on account of its small size and relatively slight importance, the variation of pit percentages is from 4.14 (Hemskirk, No. 13) to 6.7 (peach variety, No. 17), a somewhat smaller difference than was found in the prunes, viz., 3.8 to 2.5 per cent. The average pit contents is 5.8 per cent, leaving about sixteen times more flesh than pits. Here, again, there is but a trifling advantage in choice, so far as the proportion between flesh and pits is concerned.

For equal weights of prunes and apricots, whole fresh fruit, the consumer receives nearly the same amount of flesh or available matter; but the apricots being some three times larger than the prunes, we have, on the average, seven apricots as against twenty-one prunes to the pound, avoirdupois.

Peaches.—The limited results obtained prevent us from making any comparisons with the figures presented for apricots and prunes. The difference between the pits in the varieties examined is too small to be considered. Lemon Cling (No. 21) has some thirty-three times more flesh than pits; Orange Cling (No. 20) shows twenty-five times more flesh.

European analyses of these fruits report figures which do not differ materially from those furnished in the above table; the average pit percentage is, for prunes, 5.4; for apricots, 5.3; and for peaches, 6.1; the weights for whole fruits not being given in the analyses at hand.

PROPORTION OF JUICE TO FLESH.

Prunes.—A glance at the figures in the table shows that the French prune (No. 3) has the largest proportion of free juice, namely, 87 per cent, nearly *seven eighths* of the flesh. Robe de Sergent (No. 5) falls but slightly below, with 84 per cent, or *five sixths* of the flesh. The driest flesh is that of No. 11, St. Catherine (unripe sample), about *one half* of it being fiber; No. 12, a later and fully ripe sample of the same name, approaches closely the general average of 73 per cent, or nearly *three fourths* the flesh. It is important to note that Hungarian (No. 7), while the largest fruit, has nearly 10 per cent less juice than the average French prune, *i. e.*, 70 against 80 per cent.

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Apricots.—The relation between juice and fiber in the flesh is quite constant, as none of the figures obtained differ more than 5 per cent from the general average (87.3 per cent), the juice amounting to about *seven eighths* of the flesh; Nos. 16, 17, and 18 (respectively, Royal, Peach, and Moorpark varieties) showing the highest proportion of juice (90 per cent), and Hemskirk (No. 13) (not fully ripe), the lowest, 82.3 per cent.

The average flesh of the apricots, from this showing, is apparently more juicy than that of the prunes, in the ratio of 7 to 6.

SUGAR CONTENTS OF THE JUICE, FLESH, AND FRUIT.

The work undertaken this season (1891) did not comprehend the determination of the different sugars (dextrose, levulose, cane sugar, etc.) contained in prunes and apricots; the length of time necessary to complete such an investigation for each sample required us to limit the work to the determination of the most important point—the total sugars.

Prunes.—By far the highest sugar percentages are found in the ripe, soft, and juicy French prunes of the various localities; the somewhat harder varieties, Wangenheim, Robe de Sergent, Fellenberg, Bulgarian, German, and Datte de Hongrie yield, on the average, 6 per cent less sugar. Although there is a difference of one month in the picking (September 28th to August 26th) of the French prunes from Mountain View and San José, yet, for the flesh and fruit, the sugar content is nearly identical, 18.6 per cent for flesh and 17.6 per cent for the entire fruit, fresh. St. Catherine (No. 12), with 22 per cent of sugar in its juice, compares well with the sugar percentage (average 22.6 per cent) in the juice of French prunes; referring these figures to the flesh and fruit, those of the St. Catherine are some 2.5 per cent less on the average. In connection with the St. Catherine, it is interesting to note the wide difference, fully 6.5 per cent, in the sugar found in No. 11 (not fully ripe) and that in No. 12 (fully ripe), picked over three weeks apart.

Among the other, or firm-fleshed prunes, the widest difference in sugar percentages is 3.8; Datte de Hongrie (No. 10) showing 12.44 per cent and Wangenheim (No. 4) 8.80 per cent for the whole fruit. A sample of dried French prunes (No. 24) ready for consumption, from same crop as No. 1, Mountain View, and referred to that, yields 47.25 per cent of sugar. This latter figure is a little over four times larger than the general average of sugar in whole fruit of the fresh prunes.

Apricots.—Both the early (picked in June) and later varieties (picked in August), with the exception of the (not fully ripe) Hemskirk (No. 13), show a remarkably close resemblance to each other in regard to sugar contents; the Royal (No. 16), with 15.06 per cent, and Peach (No. 17), with 15.72, the highest in sugar, showing but about 2 per cent more than the general average, 13.34 per cent, for the juice. Taking the general averages of sugar in the juice of prunes and apricots (columns 22 and 23), we find that the prunes stand a trifle over 3 per cent the higher; for the flesh, and for the whole fruit, the difference is considerably less, viz., about 1 per cent. Apricots, then, according to these determinations, range much lower in sugar (6 per cent) than the Prune d'Agen, the difference being nearly the same, as already noted above for the harder prunes.

Comparison with European Fruits.—European reports of these fruits show that the *juice* of prunes, on the average, contains 6.15 per cent

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sugar; apricots, 4.69 per cent (one case is reported of a small variety of apricots with 16.5 per cent sugar), and for peaches 4.48 per cent, these figures being from two and one half to three times less than those herein presented for these fruits as grown in Central California. There seems thus to be good cause for the preference they have so quickly attained in the market.

By reference to the small table following the relations to each other of the average *sugar* and *acid* contents of some California fruits will readily be seen. For convenience of comparison the acid is expressed in terms of sulphuric acid (SO_3):

	Juice.		Flesh.	Whole Fruit.
	Acid, Per Cent.	Sugar, Per Cent.		
Apricots from Niles	.63	13.34	11.56	10.76
Prunes from Niles, San José, and Mountain View	.43	16.70	12.30	11.65
French prunes, from Niles, San José, and Mountain View	.25	22.60	18.33	16.91
Grapes from various localities	.50	24.00	23.00	20.70
Oranges from various localities	1.34	9.65	6.20	4.70
Peaches from Anderson, Shasta County, and Chico	.24	17.00	13.40	12.50

ACID IN THE JUICE.

Prunes.—The maximum, nearly 1 per cent, is at once seen in the Hungarian (No. 10); the minimum, 0.23 per cent, in the Prune d'Agen (No. 1); the average, 0.43 per cent, being almost twice the minimum.

Apricots.—While the acids differ from 0.50 per cent to 0.80 per cent, they do not show as great a diversity as the prunes in this respect. In both fruits it appears that low acids are combined with high sugars. European analyses, which report the acid in terms of malic, when corrected for sulphuric give for prunes 0.51 per cent, apricots 0.70 per cent, and peaches 0.55 per cent, which do not differ much, except for peaches, from those we report.

NUTRITIVE VALUES—NITROGEN CONTENTS.

The flesh-forming ingredients of any article of food being of great importance as regards its proper uses (see Bulletin 93 of the department, relating to oranges and lemons), it is of special interest to compare in this respect the prune and apricot to other fruits, and the different varieties of prunes and apricots amongst themselves. As heretofore set forth in Bulletin 93, the California orange with 1.20 per cent albuminoids, while lower in these ingredients than the Sicilian with 1.73 per cent, was rated the *first* in this respect amongst our fruits. In so far as our later work bears in this direction we must accord to the apricot (edible portion alone) an equal place, albuminoids being 1.19 per cent; the prune (0.76 albuminoids) takes the *second* place, leaving the other fruits, grapes, bananas, apples, and pears (from European data) to stand in the order now mentioned till we find opportunity to study them. The apricot *as a whole* (pits included) shows 1.43 per cent albuminoids, or 0.23 per cent more than the orange.

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Among the *prunes* the highest percentages of albuminoids (0.94) is found in the flesh of German (No. 9) and the ripe St. Catherine (No. 12), closely followed by that of the Prune d'Agen with 0.86 per cent; the lowest of the series being the Robe de Sergent (No. 5), with only 0.52 per cent—about 0.2 per cent less than the average for the flesh of all the prunes, which is 0.76 per cent.

Contrary to statements in our previous publications (Bulletins 90 and 93 of this department), in which, according to European data, the orange stands second (grapes being first) among fruits in the quantity of mineral matter withdrawn from the soil, we find that, weight for weight, the apricot has the *second* place; and that the prune and the orange

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Total	99.92	99.85	
	100.05	99.90	
	100.11	99.74	
Less Excess of Oxygen Due to Chlorine	.05	.15	
	.05	.14	
	.05	.40	

FRENCH		
Whole fruit		
Flesh		
Pits		
ROYAL		
Whole fruit		
Flesh		
Pits		

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have about an equal right to the *third* place, thus again bringing plainly before us the fact that we cannot safely use European results, as heretofore, as a basis of comparison for our fruits.

Upon the basis of the preceding table of this publication, and those given in Bulletin 93, we have prepared the following tabular view of the amounts, in pounds, of soil ingredients extracted by the different fruit crops that will have to be replaced by fertilization:

Fruits.	Total Ash Pounds.	Potash Pounds.	Phosphoric Acid Pounds.	Nitrogen Pounds.
GRAPES.				
European—				
In each 1,000 pounds	8.80	5.00	1.52	1.70
APRICOTS.				
European—				
In each 1,000 pounds	4.90			.86
Crop of 30,000 pounds	147.00			25.80
California—				
In each 1,000 pounds	5.16	2.16	.71	1.29
Crop of 30,000 pounds	154.80	84.98	21.38	68.70
PRUNES.				
European—				
In each 1,000 pounds	6.30	3.73	.95	1.22
Crop of 30,000 pounds	189.00	111.90	28.53	36.60
California—				
In each 1,000 pounds	4.03	2.653	.53	1.48
Crop of 30,000 pounds	120.90	79.70	15.95	44.40
ORANGES.				
European—				
In each 1,000 pounds	6.07	2.78	.67	2.69
Crop of 20,000 pounds	121.40	55.60	13.40	53.80
California—				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60

California *prunes* thus appear to draw much less upon all the mineral ingredients which have to be replaced by fertilization than the European. The latter, however, draw much more lightly than the former upon nitrogen. *Apricots*, both of California and European growth, stand, in total amount, about equal as to mineral ingredients withdrawn. As to nitrogen, the California fruit draws two and one half times as much, showing the very material difference in the relative proportions of the vital soil ingredients among themselves.

Potash.—In the ashes of prunes and apricots, as in the orange, potash is seen to be the leading ingredient (at least one half the ash), ranging somewhat higher in the former two fruits. In its distribution, as between pits and flesh, the greatest difference is shown by the European prune. For apricots we have no foreign data. Although potash constitutes so large a portion of the ash of these fruits, its replenishment to the soil will be delayed long beyond the addition of other fertilizing ingredients, because most California soils are naturally so well stocked with it that available potash for the current demand will in many cases be adequately supplied for many years.

Phosphoric acid is not so heavily drawn upon, nor do our fruits in any case, so far examined, quite reach the same demand upon the soil in this respect as the European. Its distribution between pits and flesh, also, is not quite so variable as that of potash. Since our soils usually

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contain a limited supply of phosphoric acid, the prune and apricot as well as the orange orchards will require *phosphatic* fertilizers first, when any are used.

Nitrogen.—The apricot here leads in its demand upon the soil in this substance, closely following the European orange. Averaging the nitrogen withdrawn by the prune and apricot, we obtain a figure but slightly greater than that for the orange; emphasizing for those fruits the same necessity of early replacement of nitrogen, and partly for the same reason, viz.: that California soils are usually not rich in their natural supply of this substance.

Of the other ash ingredients, it will be seen that *lime* is quite constant, although much less in amount (for prunes) than European standards show. Especially is this difference seen in the comparison of the ash analyses of the flesh and pits. In the orange ash the lime content far exceeds that of either the prune or apricot; accordingly, as our soils generally contain plenty of lime, even for oranges, we would rarely expect to fertilize with a view to its replacement. *Soda* is seen to be much higher here than in European analyses of the ash of the prune; this is probably explained by the fact that California soils, like those of other arid regions, contain much more soda than the European.

CALIFORNIA ORANGES AND LEMONS.

By GEORGE E. COLBY.

The following are descriptive notes upon citrus fruit of the crop of 1892; and tabulated proximate analyses of eighteen samples of oranges and nine samples of lemons of the crop of 1892, and for comparison the averages of analyses of crop of 1891 already reported, together with the ash analyses of eleven oranges and four lemons. The results and discussion are in continuation of the work presented in Bulletin No. 93 of this Station.

Description of Oranges Received. (Crop of 1892.)

(For description of oranges received, crop of 1891, see Agricultural Report 1890, pages 107–109, or Bulletin No. 93.)

NAVELS.

No. 28. *Phœnix, Arizona.*—The Arizona Improvement Company, grower. Sample was received on December 18, 1891. It was above the usual size of Navels, excellent in condition; high in color, with thick and brittle skin, heavy "rag," coarse structure, and rather "watery" taste. The Improvement Company, in its letter accompanying the samples, writes as follows: "The orange grove where these specimens were grown is about 7 miles northeast of Phœnix, in the Salt River Valley, Arizona. There are twenty acres in bearing now. All the trees are thrifty. The grove is protected by foothills, which lie about a mile to the north. The soil is decomposed granite; there have been no fertilizers used. The summers are long and warm here, the thermometer often going as high as 112° and 115° in the middle of the day. The coolest time in mid-

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summer is just before daylight, when the thermometer is about 40° lower."

Nos. 29 and 30. *Redlands, San Bernardino County.*—Sent by Mrs. E. Devenport; Mr. Hewitt, grower. Samples received on February 23, 1892. The small-sized Navels (No. 29) were slightly overripe, and nearly typical as to shape; skin was thin, slightly ribbed; very juicy and of excellent flavor. The large-sized sample (No. 30) was in good condition; skin thick; flesh tender and pleasant tasted, but rather dry —distinctly below the smaller sized orange in quality in this case as in others.

No. 31. *Duarte, Los Angeles County.*—"Thomson's Improved Navel." A. C. Thomson, grower and originator. Sample was received on March 18, 1892, from the California State Citrus Fair exhibit, held in Los Angeles, March 2, 1892. Condition good; shape elongate; size, skin, and "rag" medium; flesh tender, juicy, and very palatable.

SEEDLINGS.

Nos. 32 and 33. *Smartsville, Yuba County.*—Jas. K. O'Brien, grower. Samples were received on March 9, 1892, in good condition, fully ripe; both rather pleasant to taste, although tart. The larger (No. 32) is a bright yellow orange of thick skin and heavy "rag." No. 33, the smaller, was of deeper color than the other, and with a remarkably thin skin.

No. 34. *Colusa, Colusa County.*—"Baldwin's Seedling." Dr. W. H. Belton, grower. Sample was received on March 25, 1892. It is a large, light yellow-colored orange, of tender rind and flesh, very sweet and palatable to the taste.

No. 36. *Lewis Creek, Tulare County.*—J. Tuohy, grower. The sample was received on March 10, 1892. It is a large, thin-skinned orange, with thick "rag," tender, juicy; and flesh of tart, but agreeable taste.

No. 39. *"Englewood," Los Angeles County.*—Daniel Freeman, grower. The sample was received on March 18, 1892, from the California State Citrus Fair, held in Los Angeles, March 2, 1892. It was an exceedingly sweet, tender-fleshed fruit, with a medium thick skin and "rag."

Nos. 40 and 60. *Santa Paula, Ventura County.*—"Havana Seedling." N. W. Blanchard, grower. No. 40 was received on June 2, 1892; No. 60 on June 24th. Both were in good condition, and both samples large, bright yellow in color, with thick, loose skin and "rag," and loose-textured flesh; No. 40, with less acid than No. 60, is rather flat and "watery" to the taste.

No. 62. *Santa Paula, Ventura County.*—"Portugals." N. W. Blanchard, grower. The sample was received on June 24, 1892. It was a flat-shaped, very thick, loose-skinned orange, poorer in quality than the Havana Seedling. Mr. Blanchard writes: "The Portugals have been improving for the last two or three years in quality; they were a sour, poor orange, and I do not consider them good now."

No. 63. *Santa Paula, Ventura County.*—"Wolfskill's Best, or Eureka." N. W. Blanchard, grower. The sample was received on June 24th. It was above medium in size, with very thick skin, loose "rag," and somewhat fibrous-textured pulp: about the same in quality as that of the Portugals.

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MEDITERRANEAN SWEET.

No. 41. *Porterville, Tulare County.*—W. H. Norris, grower. The sample was received on March 18, 1892, from the California Citrus Fair, Los Angeles. A typical orange of this variety, with thick skin and "rag," tender flesh and agreeable flavor.

No. 61. *Santa Paula, Ventura County.*—"Mediterranean Sweet, or large St. Michaels." N. W. Blanchard, grower. The sample was received on June 24, 1892. A large orange, evidently not St. Michaels; of thick, heavy skin and "rag," with a dryish, coarse-textured pulp; poor in quality and flavor.

ST. MICHAELS.

No. 42. *Porterville, Tulare County.*—W. H. Norris, grower. The sample was received on March 18, 1892, from the California State Citrus Fair, Los Angeles. This was a large sample of this variety; good color and condition; rather heavy rind and fibrous-textured pulp; taste very agreeable.

No. 59. *Santa Paula, Ventura County.*—N. W. Blanchard, grower. The sample was received on June 24th. A typical paper rind St. Michael, with tender flesh and pleasant acid; in quality, by far the highest for the Santa Paula oranges.

RUBY BLOOD.

No. 43. *Nordhoff, Ventura County.*—S. Thacher, grower. The sample was received on March 18th, from the exhibit of the California State Citrus Fair, Los Angeles, March 2, 1892. A small, deep red-tinted, juicy orange, rather flattened at base and apex; thick skinned, with very fibrous, tough flesh, and wine-colored juice; taste very tart, but pleasant.

KING.

No. 46. *Riverside.*—J. C. Castleman, grower. The sample was received on March 18, 1892, from the exhibit at Los Angeles. A small, very rough, thick-skinned orange with immense "rag" and a very dry, tough, and fibrous flesh; acid sharp. The quality is evidently inferior.

King. (*Crop 1887.*)

No. 44. *Riverside.*—J. E. Cutter, grower. The sample was received on July 7, 1887. Condition good; skin thin and smooth; separates readily and cleanly from the flesh; pulp delicate, very juicy and sweet; acid pleasant. Under date of June 29, 1887, Mr. Cutter writes: "About the year 1880 or 1881, Dr. S. R. Magee, of Riverside, received several trees of this 'King' orange from Saigon, Cochin China, under the seal of the government of that country. A year later I obtained buds from these small trees, and putting them into eight-year-old trees, one year ago obtained the first fruit from them—two specimens only."

No. 45. *Riverside.*—L. M. Holt, sender. The sample was received on July 7, 1887, in good condition. A smooth, thin-skinned orange, of tender, juicy, rich, sweet flesh, and agreeable acid. On July 1, 1887, Mr. Holt writes: "They are from Japan, a very superior kind, and are the first ever grown on this coast."

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Description of Lemons Received. (Crop of 1892.)

(For description of lemons received, crop of 1891, see Agricultural Report, 1890, page 109, or Bulletin No. 93.)

EUREKA.

No. 48. *Nordhoff, Ventura County.*—S. Thacher, grower. The sample was received on March 18, 1892, from the California State Citrus Fair exhibit, March 2, 1892. The specimen is small-sized, thin-skinned, and quite juicy, notwithstanding its dry and fibrous pulp; seeds are small and poorly developed.

No. 49. *"Englewood," Los Angeles County.*—Daniel Freeman, grower. The sample was received on March 18, 1892, from the California State Citrus Fair exhibit, Los Angeles. Of good size; skin quite heavy and thick; apex of the fruit pointed and quite fleshy; pulp rather hard and dry; few small seeds.

No. 50. *Santa Paula, Ventura County.*—N. W. Blanchard, grower. The sample was received on June 2, 1892. An average-sized, fairly juicy lemon.

LISBON.

No. 52. *Lewis Creek, Tulare County.*—J. Tuohy, grower. The sample was received on March 10, 1892. A medium-sized, thin-skinned lemon, with only a fair amount of juice; pulp rather tender.

No. 53. *Santa Paula, Ventura County.*—N. W. Blanchard, grower. The sample was received on June 2, 1892. Average as to size, but very thick-skinned; seeds were poor and undeveloped.

UNNAMED VARIETIES.

No. 54. *Porterville, Tulare County.*—W. H. Norris, grower. The sample was received on March 18, 1892. From the California State Citrus Fair exhibit, Los Angeles. A small lemon, with a very hard, thin skin, not ribbed.

No. 56. *Redlands, San Bernardino County.*—Mr. Hewitt, grower. The sample was received on March 1, 1892. Slightly above medium size, with thick skin and agreeable flavor.

No. 57. *Matillija Cañon.* Mrs. Robert Lyon, grower. The sample was received on March 18, 1892, from the exhibit at Los Angeles. Nearly double the usual size; rind smooth; fruit slightly pointed at base; pulp only moderately juicy, and very sharp.

SEEDLESS (NEW VARIETY).

No. 58. *Azusa, Los Angeles County.*—McNeil & Claussen, growers. The sample was received on March 18, 1892, from the exhibit at Los Angeles. A very large fruit, of remarkably thick rind and "rag," fleshy apex, and dry, tough, fibrous pulp; no seeds.

Discussion of Analytical Results.

The accompanying tables present the results of analyses of the above samples of the crop of 1891–92, together with a few made previously of the crop of 1886–87, and heretofore unpublished. To the tables are

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added, for purposes of comparison, the average of analyses of each variety, as given in the annual report for 1890–91.

Table A presents the physical and proximate analyses; Table B, the results of an examination of the ash.

In order to bring out more clearly than is shown by the tables, the prominent points of similarity or difference, we discuss briefly the data here presented, as well as that heretofore published. Herein, also, will be repeated such parts of previous discussions as avail for briefness and comparison, without further remark.

ORANGES.

Proportion of Rind to Flesh.—Considering the matter, first, from the standpoint of the consumer, it seems that although the Navel is the largest of oranges, it has, contrary to the popular impression, no advantage, with respect to the proportion of skin to flesh, over the Seedlings, Mediterranean Sweet, St. Michael, or Malta Blood. The average Navel can very fairly be considered as made up of 72 per cent of flesh, with 28 per cent of rind; the average seedling, 75 per cent of flesh and 25 per cent of rind; the average Mediterranean Sweet and Malta Blood, like the Navel, with 72 per cent of flesh and 28 per cent of rind; the average St. Michael, with 80 per cent of flesh and 20 per cent of rind, representing the orange containing the least waste material.

A Florida Navel, analyzed at the Florida Experiment Station (Bulletin No. 17, 1892), contained 74.35 per cent of flesh (average weight, in grains, 217); a Malta Blood showed 76.1 per cent of flesh, and the average of the varieties there grown and examined, exclusive of the Mandarin and Tangerine, 76 per cent of flesh. The amount of flesh in the above mentioned Mandarin and Tangerine is, respectively, nearly identical with that of those presented in our table, viz., about 75 per cent.

Juiciness, or Proportion of Juice to Flesh.—A comparison of the figures, especially the average, in the large table, shows that, of the named varieties examined, the Navel is the driest, and while the St. Michael has the largest proportion of juice, it is closely followed in that respect by the Mediterranean Sweet, Seedlings, and Malta Blood. It is interesting to note that the King orange, one so much admired in Southern California, seems to promise to equal, if not exceed, the St. Michael in juiciness. These facts will be better understood by reference to the small table below, which gives the percentage ratios.

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Average Percentage Ratios.

Variety.	No. of Samples.	Proportion of Rind to Flesh.		Proportion of Pulp to Juice in Flesh.	
		Rind.	Flesh.	Pulp.	Juice.
NAVELS.					
Crop of 1885	4	29.0	71.0	32.0	68.0
Crop of 1891	5	28.4	71.6	39.0	61.0
Crop of 1892	4	28.2	71.8	41.0	59.0
Average	13	28.5	71.4	37.4	62.6
SEEDLINGS.					
Crops of 1880–85	7	26.0	74.0	26.0	74.0
Crop of 1891	None.				
Crop of 1892	6	24.0	76.0	37.0	63.0
Average	13	25.0	75.0	31.5	67.5
MEDITERRANEAN SWEET.					
Crops of 1885–86	3	30.0	70.0	25.0	75.0
Crop of 1891	3	27.0	73.0	33.0	67.0
Crop of 1892	2	30.0	70.0	41.0	59.0
Average	8	28.8	71.1	32.0	68.0
ST. MICHAELS.					
Crops of 1885–86	5	19.0	81.0	23.0	78.0
Crop of 1891	5	19.0	81.0	31.0	69.0
Crop of 1892	2	22.0	78.0	40.0	60.0
Average	12	19.5	80.5	29.1	71.3
MALTA BLOOD.					
Crop of 1885	1	27.0	73.0	30.0	70.0
Crop of 1891	3	31.0	69.0	36.0	64.0
Crop of 1892	None.				
Average	4	30.0	70.0	34.5	65.5
KING.					
Crop of 1887	2	23.2	76.8	23.0	77.0
Crop of 1892	1	49.3	50.7	50.0	50.0
Average	3	31.9	68.1	32.0	68.0

Evidently the hard and solid, although thin, rind of the Navel is heavier than the more "corky" one of the Seedlings and nearly equal to that of the Mediterranean Sweet. The Navel, No. 4 (1891), from Riverside, with 17.5, the Seedling, No. 33 (1892), from Smartsville, with 18.5, and the Navel, No. 8 (1891), from Pomona, with 18.6, however, show the lowest rind percentages of any samples yet examined, save St. Michael, No. 5 (1891), from Pomona, the genuine "paper rind," with 14.4. The highest rind percentage (49.3) of all is found in the King orange, No. 46 (1892), from Riverside. The study of the conditions contributing to thinness of rind will be of high commercial importance.

Sugar Contents of the Juice.—The figures for sugar contents, in the large table, show that the Navels, Seedlings, and St. Michaels of the last crop are higher, on the average, than those for the same varieties of 1891, while those of the Mediterranean Sweet are about the same; Seedling, No. 39, from "Englewood," has the *maximum* sugar, 14.70 per cent.

Ranging from 1.5 to 2.5 per cent lower than the above maximum we note the Navel, No. 31, from Duarte, with 13.10 per cent; Ruby Blood, No. 43, from Nordhoff, with 13 per cent; Seedlings, Nos. 33 and 34, from Smartsville and Colusa, with 12.50 per cent, and St. Michael, No. 42,

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Number	Variety.	Place of Product
	ORANGES.	
	Navel.	
28	Washington	Phœnix, Salt River Valle
29	Washington (small) ‡	Lugonia
30	Washington (large)	Lugonia
31	Thomson's Improved	Duarte
	Average, 1892	
	Average, 1891	
	Average, 1891 and 1892 (8–9 samples)	
	Seedlings.	
32	Seedling (large)	Smartsville
33	Seedling (small)	Smartsville
34	Baldwin's	Colusa
35	Seedling (?)	Tulare
36	Seedling	Tulare
37	Seedling	Kings River
38	Seedling (?)	Montecito, Santa Barbar
39	Seedling §	"Englewood"
40	"Havana Seedling" ‖	Santa Paula
60	"Havana Seedling"	Santa Paula
62	"Portugals"	Santa Paula
63	"Wolfskill's or Wilson's Best, or Eureka"	Santa Paula
	Average, 1892 (6 samples)	
	Mediterranean Sweet.	
41	Mediterranean Sweet §	Porterville
61	"Mediterranean Sweet or Large St. Michaels"	Santa Paula
	Average, 1891	
	St. Michaels.	
42	St. Michaels §	Porterville
59	St. Michaels ¶	Santa Paula
	Average, 1891	
	Malta Blood.	
	Average, 1891	**Pomona**
43	*Ruby Blood*	Nordhoff
	King.	
44	King	Riverside
45	King	Riverside
46	King	Riverside
	Average, 1887–1892	**Riverside**
21	*Tardive* (*Valencia Late*)	Pomona
22	*Tangerine*	San Gabriel
47	*Mandarin*	Southern California
	LEMONS.	
48	Eureka	Nordhoff
49	Eureka	"Englewood"
50	Eureka §§	Santa Paula
51	(?)	Tulare
52	Lisbon	Tulare
53	Lisbon §§	Santa Paula
54	(?)	Porterville
55	(?)	Kings River
56	(?)	Redlands
57	(?)	Matillija Cañon
58	Seedless (new variety)	Azusa
	Average, 1892	
	Average, 1891	
	Average, 1891 and 1892 (13 samples)	

* About 30 grams are equivalent to 1 ounce. † Thirty cubic centimeters (c.c.)
¶ Nitrogen in rind on whole, fresh fruit, 0.045 per cent. §§ Picked in February, 18

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from Porterville, with 12.20 per cent; all of which run upward of 2 per cent more than the figures for the same varieties examined for the crop of 1891.

The average sugar content of the fully ripe Navels, from all localities, is 11.13 per cent; that of 1892, apart from the Arizona Navel, No. 28, contained 11.60 per cent of sugar (samples gathered in February and March), as against 10.80 per cent of sugar in the Navels of 1891 (picked in April and May). The Arizona Navel, above referred to, was picked in the early part of December, 1891, quite two and a half months earlier than the California Navels of the same crop, and contained 11.52 per cent of sugar. Somewhat higher numbers for sugar percentages (12.63 on the average) are shown by the ripe Seedlings, gathered mostly in March, 1892. The Seedling, No. 9 (1891), from Smartsville, with 10.10 per cent of sugar, was gathered in January, indicating a very early maturity. We find but little variation in the sugars of the average ripe Mediterranean Sweet (sugar about 10 per cent) and St. Michael (sugar 9 per cent), though the dates of picking vary considerably for the two crops.

Comparing these data with those of previous years, partly tabulated below, we find that the sugar percentages of the Navels and the Seedling appear to have risen; while for the Mediterranean Sweet and St. Michael apparently but little change has taken place.

Our study, limited as yet, of the King, Tangerine, and Mandarin oranges points to interesting results: The King of 1887 averaged 13.95 per cent of sugar; for the three samples examined (crops 1887 and 1892), 13.17 per cent, thus establishing, in as far as the results go, the claim for its superiority in this respect. It is unfortunate that this King orange possesses other qualities which do not recommend it for growers' uses, as will be seen from the following information, for which we are indebted to Mr. J. E. Cutter, of Riverside: "It is a good bearer, but more than common is susceptible to frost; it is set as thickly as a vine with thorns. The fruit is rather lacking in uniformity; usually below medium size, but large in case of short crop. The peel is coarse, rough, and has a generally unattractive appearance, which is against it for market purposes. It attains its best quality in summer and autumn, when its thoroughly ripened acids and sugars blend to form the most piquant and refreshing of citrus fruits. It will be seen that such a variety is a failure for growers' and dealers' uses, and only desirable for home use in summer."

Both the Mandarin, No. 47, and its close relative, the Tangerine, No. 22, yield high returns for *cane* sugar; that of the Mandarin being the maximum of the whole series—9.67 per cent—not far from the average *total* sugar of the Mediterranean Sweet and St. Michael, and 2.20 per cent above that of the Tangerine. Next in order, on the average, in this respect comes the Malta Blood, King, and Navel.

To what extent the proportion of *cane* sugar determines the sweetness to the taste is a matter not yet fully understood; the proportion between the other two sugars (grape and fruit), not yet determined, being an essential factor in the case.

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Average Percentages of Sugar and Acid.

Variety.	No. of Samples	Sugar.	Acid.
NAVELS.			
Crop of 1885	3	9.89	1.04
Crop of 1891	6	9.92	1.02
Crop of 1892	4	11.57	1.02
Average	**13**	**10.42**	**1.02**
SEEDLINGS.			
Crop of 1885	5	9.50	.94
Crop of 1891	1	10.09	1.68
Crop of 1892	6	12.63	1.29
Average	**12**	**11.11**	**1.17**
MEDITERRANEAN SWEETS.			
Crop of 1885	1	10.00	1.09
Crop of 1891	3	9.70	1.38
Crop of 1892	2	9.70	1.29
Average	**6**	**9.80**	**1.30**
ST. MICHAELS.			
Crop of 1885	3	9.70	1.14
Crop of 1891	5	8.71	1.15
Crop of 1892	2	10.10	1.21
Average	**10**	**9.30**	**1.16**
MALTA BLOOD.			
Crop of 1885	1	----------	1.43
Crop of 1889	3	10.30	1.61
Average	**4**	----------	**1.56**
KING.			
Crop of 1887	2	13.95	1.32
Crop of 1892	1	11.60	1.34
Average	**3**	**13.17**	**1.49**

By reference to the small table on page 95 of this report, the average amount of sugar contained in some California fruits will readily be seen.

Acid in the Juice.—First, comparing the average acid percentages in the crops of 1891 and 1892 in the table just above, we find that the acid in the Navels stands the same; in the last crop of the Mediterranean Sweets and St. Michaels it is a trifle less; in the Seedling it also appears to be less in 1892, but identical with that of same crop of Mediterranean Sweets.

The Malta Blood, No. 18 (1891), with 2.04 per cent, still leads in acid contents; the Ruby Blood, No. 43 (1892), from Nordhoff, with 1.92 per cent; the Riverside King, No. 46 (1892), with 1.84 per cent, and the Seedling, No. 36 (1892), from Tulare, with 1.71 per cent, being the only ones which run anywhere near it.

The next highest acids are found in samples of Mediterranean Sweet, No. 41 (1892), from Porterville, with 1.67 per cent; Seedling, No. 33 (1892), from Smartsville, with 1.64 per cent, and St. Michaels, No. 42 (1892), with 1.55 per cent—figures which indicate that these varieties stand in about the same relation to each other in acid contents as they did the previous year (1891); however, those of the last crop present, on the whole, somewhat the widest range in this respect. As heretofore pointed out, the St. Michaels, Valencia, and Tangerine, in contrast to the Malta Blood, rank among the varieties of low acid, combined, in the first two kinds, with low sugar (about 9 per cent), that of the Tangerine being considerably in advance of the others, namely, 11 per cent sugar.

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The Mandarin (No. 47) yields the least acid (0.36 per cent) of all the oranges examined, and like the Tangerine it contains also one of the highest sugar percentages (13.84).

With regard to the Navel, the same remarks apply to the acid of the last crop as to that of 1891, and emphasize previous statements that even the samples gathered in January and February have low acid percentages; still more is this seen in some of the later samples of 1891, gathered in April and May. The Pomona fruit, No. 6 (1891), shows the lowest acid (0.77 per cent) of the California samples; the minimum of all, 0.66 per cent, being found in the Arizona Navel, thus accounting partly for its "watery" taste, above mentioned, as compared with the taste of the medium-sized California fruit; it however contains as much sugar as any of them. In the aggregate, the average acid percentage of the Navel (1.00) is the lowest of all, with as high average sugar (10.50 per cent) as any of the other largely grown varieties, excepting the Seedlings. These data, together with its firm flesh, thin and smooth rind, and excellent keeping qualities, explain sufficiently the great preference given it in our markets.

A glance at the above table of averages at once shows that the earlier crop, on the whole, contained less acid than did those of the last two years.

Comparing these results, obtained in 1891 and 1892, with those in previous publications of this Station, 1879–1887, we note, first, an apparent increase in the average weight of the several varieties. We also find that while the percentages of rind show very nearly the same average as in 1891 and 1892, there is a marked discrepancy in respect to juiciness, the pressed pulp averaging about 25 per cent less in earlier specimens. How far these differences may be due to influences of season or accident in sampling, is difficult to decide with the data before us; the more so, as the acid and sugar percentages show very nearly the same absolute, as well as relative, figures. Increased age of the bearing trees may possibly account for some of these differences.

Nutritive Values—Nitrogen Contents.—The flesh-forming ingredients (albuminoids) of any article of food being of great importance, as regards its proper uses, it is of special interest to compare, in this respect, the oranges to other fruits, and the different varieties of oranges amongst themselves. For the former purpose we here present our data, with that of some European fruits, in the following table of average percentages of albuminoids:

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Average Percentages of Albuminoids.

Variety.	No. of Samples	In Whole Fresh Fruit.		
		Total.	Flesh, or Edible Portion.	Rind or Pits.
ORANGES.				
California	35	1.14	.76	.38*
European (Sicilian)	.....	1.78	.....	.....
APRICOTS.				
California	5	1.427	1.19	.237
European	.....	.49	.....	.....
PRUNES.				
California	12	.928	.760	.168
European	.....	.780	.....	.....
APPLES AND PEARS.				
European	.....	.375	.....	.....

*Average of three samples of 1892 and eight samples of 1893, largely grown varieties. The analyses of the latter crop samples will be fully reported in a later publication of this Station.

These results, meager it is true so far as the amount of albuminoids in the rind of the orange is concerned, help us to begin to form proper conclusions upon our fruits without calling up European works as a guide. Apparently, then, among California fruits the orange can have but *second* place (apricots having the *first* and prunes the *third*) in the amount of albuminoids they contain in their edible portions, as well as in total fruit. And, as before reported, our oranges show materially less of these substances, on the average, than do the Sicilian (1.14 per cent as against 1.78 per cent); therefore, we must conclude that they are less nourishing. Much lower percentages than 1.78, however, are quoted for oranges from other European sources; the average for Florida oranges for the whole fruit is .775 albuminoids (Bulletin No. 17, Florida Expt. Station).

The *maximum* percentage of albuminoids (1.682) of the entire series is found in the Ruby Blood, No. 43, only 0.1 per cent less than that of the Sicilian (1.78 per cent), but higher than that of the Pomona Navel, with its 1.54 per cent, the maximum figure for the crop of 1891. On the whole, there is apparently but little change in the amounts of albuminoids in the different varieties for both seasons, thus leaving, after the Ruby Blood, the St. Michael, Navel, Seedlings, Malta Blood, and Mediterranean Sweet to stand in the order named. The more extended work of this season upon the named lemons, also fails to show that they have varied from the average of about 1 per cent albuminoids, as set forth for crop of 1891.

Amount and Composition of Ash.—The table below gives in detail the amount and composition of the ash of representative samples of the several varieties. It will be noted for the crop of 1891 that the average ash percentage in the oranges is only four fifths of that in the lemons; also, that the average orange is somewhat richer in potash and in phosphoric acid than the lemon, but the latter takes up materially more of lime and less of magnesia. Potash is the prominent ash ingredient most heavily drawn upon from the soil. Some notable differences occur among the ash ingredients of the two seasons; however, as the varieties

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of oranges analyzed this last season are not largely grown, we will only call attention to the most salient ones. Potash in both the Ruby Blood from Nordhoff, and King from Riverside, is less than that in any of the other ashes, even though the fruit is from the same locality. Another point about the Ruby Blood is that it contains a high percentage of phosphoric acid—as much as 2.50 per cent more than the average (12.4) for all the oranges—yet much below that of the Eureka lemon from Tulare, with its 19.6 per cent. Lime reaches its maximum (37.53 per cent) in the King orange, that of the Eureka lemon from Nordhoff being nearest to it (36.07 per cent).

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TABLE B.

Analyses of the Ash of California Oranges and Lemons, 1891 and 1892.

Number.	Variety.	Place of Production.	Percentage of Pure Ash.	Composition of the Pure Ash.												
				Potash	Soda	Lime	Magnesia	Peroxide of Iron	Br. Oxide of Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less Excess of Oxygen, due to Chlorine	Total
	ORANGES (*Crop of 1891*).															
1	Navel	Marysville	.399	55.26	1.39	16.37	5.50	.41	.28	12.41	6.81	.55	1.04	100.02	.23	99.79
4	Navel	Riverside	.451	49.07	3.30	26.42	5.08	.42	.44	9.80	4.23	.79	.63	100.18	.13	100.05
6	Hill Navel	Pomona	.407	47.51	3.06	17.50	6.33	1.41	.24	14.15	7.91	.98	1.00	100.09	.22	99.87
9	Seedling like Med. Sweet	Smartsville	.529	43.90	2.31	27.77	5.26	2.00	.18	13.10	4.34	.53	.59	99.98	.12	99.86
11	Mediterranean Sweet	Riverside	.413	51.25	2.41	18.78	4.76	.62	.32	14.46	5.58	.85	.92	99.95	.20	99.75
13	St. Michaels	Marysville	.477	47.60	4.09	24.70	6.96	1.18	.40	10.00	4.84	.38	.63	100.18	.18	100.00
15	St. Michaels	Pomona	.556	45.82	2.85	27.20	4.29	.97	.39	12.99	3.93	.31	1.37	100.13	.30	99.83
18	Malta Blood	Pomona	.454	52.20	1.48	19.07	4.75	.84	.64	14.71	4.29	1.06	.95	99.99	.20	99.79
22	Tangerine	San Gabriel	.461	47.87	1.67	26.65	5.48	.94	.45	9.75	5.36	.63	1.23	100.03	.27	99.76
	Crop of 1892.															
43	*Ruby Blood	Nordhoff	.590	40.31	5.57	25.57	5.99	.24	.65	15.02	4.47	1.52	.66	100.00	.14	99.86
46	*King	Riverside	.714	35.12	2.66	37.53	5.31	.45	.54	10.65	6.06	1.20	.46	99.88	.10	99.88
	LEMONS (*Crop of 1891*).															
24	Eureka	Pomona	.632	45.32	2.03	34.07	4.00	.28	.28	10.19	2.74	.54	.51	99.96	.11	99.85
26	Eureka	San Gabriel	.535	51.20	1.50	25.67	4.80	.58	.28	12.00	2.94	.68	.27	99.92	.05	99.87
	Crop of 1892.															
52	*Lisbon	Tulare	.512	44.35	4.39	25.17	6.12	.87	.53	12.67	4.15	.92	.88	100.05	.19	99.87
48	*Eureka	Nordhoff	.784	30.05	3.00	36.07	5.58	1.36	.71	19.63	2.48	.85	.27	100.00	.06	99.94
	AVERAGES OF ANALYSES.															
	Oranges (9 analyses)		.432	48.94	2.50	22.71	5.34	.97	.37	12.37	5.25	.65	.92	-------	------	99.98
	Lemons		.526	48.26	1.76	29.87	4.40	.43	.28	11.09	2.84	.66	.39	-------	------	99.98

*These oranges are not largely-grown varieties, and hence are not included in the general average. Analysed by Marvin Curtis, student, Agricultural College.

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Draught upon the Soil Ingredients.—As will be seen by reference to Bulletin No. 88, of this Station, and also to Bulletin No. 61, California State Board of Horticulture (Crops and Fertilizers, by Prof. E. W. Hilgard), the orange stands *second* (grapes being first) among orchard fruits in the quantity of mineral matter withdrawn from the soil. Heretofore (previous to 1891) we have been obliged to base all conclusions bearing upon the ash and nitrogen of these fruits on European data; we are now enabled to present for oranges and lemons the outcome of California growth. The following summary (based on averages from the large table) shows, in tabular form, the amounts in pounds of the soil ingredients extracted by an orange or lemon crop that will have to be replaced by fertilization:

Ingredients Withdrawn from the Soil by Citrus Fruits.

	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
ORANGES.				
European (seedless)—				
Crop of 1,000 pounds	6.07	2.78	.67	2.69
Crop of 20,000 pounds	121.40	55.60	13.40	53.80
California—				
Crop of 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60
Florida—*				
Crop of 1,000 pounds	9.16	4.76	.79	1.24
Crop of 20,000 pounds	183.20	95.20	15.80	24.80
LEMONS.				
California—				
Crop of 1,000 pounds	5.57	2.69	.61	1.51
Crop of 20,000 pounds	111.40	53.80	12.20	30.20

*From figures in Bulletin No. 17, Florida Experiment Station.

It thus appears that so far as oranges are concerned, the California fruit draws materially less upon all the soil ingredients (nitrogen excepted) that have to be replaced by fertilization; while as regards the lemon, it approaches closely to the European standard for the orange, save in the much smaller draught upon nitrogen.

There is, of course, no material difference in the relative proportions of ash ingredients among themselves, or toward nitrogen.

Potash is seen to be the predominating ingredient, amounting to quite half of the weight of the ash; it is therefore highly important that the supply of this substance should be kept up. But fortunately, as has been shown by previous investigations of this Station, the supply of this substance in California soils and irrigation waters is exceptionally large, so that in many cases the current demand of the fruit will be amply supplied, in the ordinary course of cultivation, for many years to come.

Phosphoric acid is not very heavily drawn upon; but as it is usually present in our soils in limited quantities only, it is probable that it should constitute a large proportion of any fertilizer used in the orange orchard.

Of *nitrogen* nearly the same may be said as regards the natural supply, especially in the southern mesa soils; and as the draught made by the orange upon this substance is very heavy, it will always be among the first to be currently supplied.

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As regards other ash ingredients, it will be seen that *lime* is the one most heavily drawn upon next to potash, although its percentage varies rather widely (from 16.37 to 37.53 per cent for oranges). The supply of lime in California soils is almost universally so ample within the orange-growing region, that no replacement of this substance in fertilization will be called for.

The not inconsiderable demand of the orange for sulphuric acid, as seen in the table, suggests that gypsum will be acceptable in this as in other respects as a fertilizing ingredient.

LEMONS.

The data concerning lemons, while as yet incomplete, are now worthy of a little more notice than we have heretofore given them, for the number of analyses now made enables us to draw a few comparisons. First, then, in the averages in the large table, we note that for the two crops there is a marked similarity in regard to rind, pulp, acid, ash, and nitrogen percentages, as well as weight.

Rind Percentages.—The Lisbon, No. 52, from Tulare, with 19.3 per cent, is the lowest for the two years, and Seedless, No. 58, the maximum, 49.8 per cent, or one half its weight, thus making the poorest showing. The average Eureka lemon, as we find it, contains 31 per cent of rind, as against 23 per cent for the average Lisbon. Only one of the unnamed varieties, No. 51, from Tulare, with 17.2 per cent, is far removed in rind contents from the average of all, 32 per cent.

Dry or Pressed Pulp Percentages.—The minimum (20.6 per cent) of this in the named varieties is found in the Lisbon, No. 53, from Santa Paula, though in the Seedless, No. 58, and in some of the unnamed samples it is a little lower. Eureka, No. 48, from Nordhoff, with its maximum of 35.5 per cent of dry pulp, represents the poorest fruit in this respect. Taking, then, the average percentages of rind and dry pulp together, we have about 56 per cent as that portion of these lemons which is, as yet, practically useless after expressing the juice.

Acid Percentages.—As above noted, the two crops do not differ materially in this all-important point; that of 1892 averages 7.53 per cent of acid in the juice, as against 7.20 per cent for 1891. Eureka, No. 48, from Nordhoff, yields the maximum, 8.33 per cent; the next in order, Eureka, No. 49, from "Englewood," has nearly as much, namely, 8.14 per cent; Eureka, No. 26, from San Gabriel, with 7.88 per cent (the highest for crop of 1891), and Lisbon, No. 52, from Tulare, with 7.84 per cent, both run about one half of one per cent less. The Seedless, No. 58, with 6.29 per cent acid, shows the minimum.

The high acid contents, and the relatively large percentage of sugar shown by the analyses, sufficiently recommend California-grown lemons to a high position in all markets.

The following brief summary of averages of analyses made at this Station of similar varieties of lemons gives some idea of a few of the differences found in various crops:

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	No. of Samples.	In Whole Fruit.				In Juice.
		Average Weight in Grains.	Rind.	Dry (Pressed) Pulp.	Juice.	Acid (Citric).
Crops 1880–87	9	127	24.2	23.8	52	6.65
Crops 1891–92	13	112	32.2	24.8	43	7.32

The earlier fruit then possessed a thinner rind, and, therefore, with a nearly constant dry pulp for all, they were more juicy; but the material increase of acid in the later fruit offsets this feature.

FURTHER ANALYSES OF CALIFORNIA OLIVES.

(Crops of 1891 and 1892.)

By G. E. Colby.

The following analyses of California olives have been made in accordance with the plan of this Station, set forth in Bulletin No. 92, which comprehends "a study of the different olive varieties cultivated in this State and of the quantity and quality of the oil produced by each."

All the samples of the earlier crop were either partly over-ripe or partly damaged. (See Report 1890, page 168.) Those of the crop of 1892, with the exception of the Newcastle olives, Nos. 15, 16, 23, and 26, which were a little shriveled, were in excellent condition, having been picked at the proper time, or maturity, for practical oil-making.

For the sake of brevity and to facilitate comparison, the analytical results obtained for both years are combined in the table below. Column 1 shows the proportion by weight between pits and flesh in the fresh fruit. Column 2 shows the proportion in which pits and flesh may be made to contribute to the oil product when fully extracted. Column 3 gives the absolute percentage of oil contained in pits and flesh. Column 4 finally gives the result of the "iodine test," much relied upon for the purity of commercial oils, as explained in Report of 1890, page 173. As we did not make any oils from olives of the crop of 1892, on account of lack of the proper machinery that had long been ordered, the examination of the oils extracted by carbon bi-sulphide for their iodine coefficient was neglected; the more so, as this test is known to yield low figures when applied to oils extracted by that solvent.

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PARTIAL ANALYSES OF SOME SAMPLES OF CALIFORNIA OLIVES AND OILS. (CROPS OF 1891-92.)

Number.	Variety.	Locality.	Date of Picking.	1 Proportion of Pits and Flesh in Fruits.		2 Percentage of Oil in Whole Fruit Yielded by		3 Percentage of Oil Contained in Fresh		4 Iodine Absorption.	
				Pits.	Flesh.	Pits.	Flesh.	Pits.	Flesh.	Oil from Pressing.	Oils Extracted by Carbon Bisulphide.
1	Manzanillo	Fresno	Nov. 4, '90	13.0	87.0	.53	19.23	4.1	22.01	80.2	76.5
2	Manzanillo	Berkeley	Jan. 20, '91	16.0	84.0	.51	21.38	3.2	25.45		76.3
6	Nevadillo blanco	Fresno	Nov. 4, '90	17.5	82.5	1.60	18.02	6.6	22.00	84.5	86.6
7	Nevadillo blanco	Mission San José	Jan. 13, '91	24.0	76.0	1.06	23.94	4.4	31.50	86.5	72.5
8	Nevadillo blanco	Berkeley	Jan. 7, '91	25.0	75.0	1.05	22.72	4.2	30.30		83.2
17	Nevadillo blanco	Mission San José	Dec. 16, '91	20.5	79.5	.94	25.65	4.7	32.06		
12	Mission	Mission San José	Jan. 8, '91	23.5	76.5	.94	19.07	4.0	24.90		
23	Mission	Newcastle	Mar. 9, '91	20.0	80.0	.61	16.55	3.07	20.68		
24	Mission	Mission San José	Dec. 16, '91	16.5	83.5	.40	18.72	2.4	21.04		
25	Mission	Fresno	Jan. 12, '92	18.0	82.0	.70	23.08	3.7	28.15		
26	Mission	Newcastle	Jan. 14, '92	17.5	82.5	.50	17.50	3.2	21.31		
13	Rubra	Fresno	Feb. 5, '91	19.5	80.5	.80	17.69	4.1	21.97		74.2
14	Rubra	Fresno	Jan. 12, '92	15.0	85.0	.80	20.00	5.2	23.53		
15	Rubra	Newcastle	Jan. 14, '92	21.0	79.0	.80	27.57	4.0	34.90		
11	Redding Picholine	Mission San José	Jan. 8, '91	29.0	71.0	1.88	21.87	6.5	30.80		73.5
18	Redding Picholine	Mission San José	Dec. 16, '91	24.5	75.5	1.17	22.99	4.7	30.70		
5	Atro-violacea	Fresno	Nov. 4, '90	23.7	76.3	1.19	13.78	5.0	18.10	83.2	80.7
16	Atro-violacea	Newcastle	Jan. 14, '92	16.0	84.0	.73	21.90	4.4	26.07		
19	Atro-rubens	Fresno	Jan. 12, '92	18.5	81.5	.80	21.26	4.2	26.10		
20	Oblonga	Fresno	Jan. 12, '92	18.0	82.0	.90	14.95	4.6	18.23		
21	Præcox	Fresno	Jan. 12, '92	17.0	83.0	.60	12.87	3.9	15.40		
3	Pendulina	Fresno	Nov. 4, '90	14.8	85.2	1.04	17.40	7.0	20.50	82.6	77.7
22	Columbella	Fresno	Jan. 12, '92	17.0	83.0	.50	15.20	3.1	18.35		
4	No name (Cerasola?)	Fresno	Nov. 4, '90	17.6	82.4	.88	16.63	5.0	20.20	80.2	73.4
9	Berkeley seedl'g No. 10 in row	Berkeley	Jan. 7, '91	30.5	69.5	1.34	18.00	4.4	26.00		80.3
10	Berkeley seedl'g No. 2 in row	Berkeley	Jan. 7, '91	36.5	63.5						

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From an examination of the above table, the following facts are deduced:

PROPORTION OF PITS TO FLESH.

The first column, exhibiting the proportion of pits and flesh contained in the fruit of the different varieties, shows that, as was to be expected from their condition, the later crop, Nevadillo No. 17, Mission No. 24, Rubra No. 14, and Redding Picholine No. 18, all yielded higher percentages of flesh than did the same varieties from the same localities in 1891. The flesh of Rubra No. 14, from Fresno, gives the maximum, 85 per cent, for these comparable varieties; this is some 5 per cent better than that of the previous year (No. 13), as well as that of Rubra No. 15 of the same crop from Newcastle; the Redding Picholines Nos. 11 and 18 show about the same difference. Mission No. 24, with 83.5 per cent of flesh, stands next to the Rubra, showing at the same time an improvement in this regard to the extent of 7 per cent. The results for the flesh of the Atro-violaceas, though not as comparable as those of the above mentioned varieties, show sample No. 16, from Newcastle, to be well in advance of No. 5 from Fresno, viz.: about 8 per cent.

Of the whole series, Manzanillo No. 1, from Fresno, shows the maximum flesh percentage, 87; the minimum, 63.5, is seen in Seedling No. 10, from Berkeley. Conversely, the percentages of pits were 13 for the former and 36.5 for the latter. Between the Manzanillo from Fresno and that from Berkeley there is a difference of 3 per cent, both in pits and flesh; this is doubtless due to the growth of the former in irrigated lands. The same can be said for the differences existing between the Nevadillo from Fresno and that from Berkeley and Mission San José. Summarily, the varieties represented could be arranged as follows, in regard to the smallness of pit and largest amount of flesh, using averages where possible:

	Variety.	Pits.	Flesh.
First	Manzanillo Pendulina	15	85
Second	Rubra	16	84
Third	Columbella Præcox	17	83
Fourth	Cerasola? Oblonga Atro-rubens	18	82
Fifth	Mission Atro-violacea	20	80
Sixth	Nevadillo	22	78
Seventh	Redding Picholine	27	73
Eighth	Seedlings, Nos. 9 and 10	38	62

"These determinations are important, because they show especially which kinds are most suitable for pickling purposes, for which the finest and largest olives, with the smallest pits, are required."

QUANTITY OF OIL.

The next determinations were made with the object of ascertaining the quantity of oil contained in the different varieties.

Referring, first, to the most comparable varieties, Nos. 7, 12, 13, and 11, crop of 1891, and their respectively corresponding samples, Nos. 17,

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24, 14, and 18, crop of 1892, we see at a glance that, save Nos. 12 and 24 (representing the Mission olives from Mission San José, average oil percentage, 19), the later crop samples all yielded higher returns for total oil contents; and among these the greatest difference (2.00 per cent) is shown between Navadillo blanco, Nos. 7 and 17, from Mission San José.

It is necessary to call attention again to the fact that of all the olives reported upon in 1891 only the Atro-violacea, No. 5, from Fresno, and the Manzanillo and Nevadillo blanco, Nos. 2 and 8, from Berkeley, showed exactly the right degree of maturity for oil-making; hence, the results obtained in 1891 cannot be taken as representing exactly the respective practical values of the several kinds. However, with the exception of the Redding Picholine, No. 11 (1891), the maturity of which was very far advanced, the other varieties give results which may be considered approximate.

Some of the varieties grown in different localities show considerable variation in yield of oil, *e. g.*, the Rubra, No. 15 (1892), from Newcastle, with 28.3 per cent oil (the maximum of all), shows some 10 per cent more than that from Fresno, No. 13 (1891); the Nevadillo blanco, No. 17 (1892), from Mission San José, 8 per cent, and Seedling, No. 8, from Berkeley, 5 per cent more than that from Fresno, No. 6; and the Atro-violacea, No. 16 (1892), from Newcastle, about 6 per cent more than the Fresno sample, No. 5 (1891). The only case in these results in which Fresno leads in oil product is in the Mission olive, No. 25, with 23 per cent, as against nearly 19 per cent for those from Mission San José, Nos. 12 and 24, and about 18 per cent for the Newcastle sample, No. 26.

The minimum of oil product is shown by Præcox, No. 21, from Fresno, with 13.4 per cent total.

It is extremely probable, therefore, that these consistent differences between the Fresno olives and those from the other localities are mainly due to the growth of the former on flat and heavily irrigated ground, tending to produce watery fruit with relatively little oil, particularly where bottom water lies near the surface.

ANALYSES OF SUGAR-BEETS.

By M. E. Jaffa.

Sugar-beets, from the San Joaquin Valley Experiment Station, Tulare; planted on sandy land of the Station. They were received in good condition on October 31, 1891, and immediately analyzed, with the following results:

Analyses of Sugar-Beets, San Joaquin Valley Experiment Station.

	Florimond Desprèz.	Butteau Desprèz.	Klein Wanzleben.	Vilmorin Desprèz.	Simon Le Grand.
Average weight of beet, in grams	229.00	292.00	283.00	294.00	185.00
Juice.					
Specific gravity	1.0480	1.0520	1.0639	1.0545	1.0563
Solid contents, per cent	11.90	12.80	15.60	13.45	13.85
Cane sugar, per cent	6.68	6.64	11.68	10.83	9.72
Ash, per cent	1.48	1.90	1.10	1.21	1.29
Coefficient of purity	55.30	51.90	74.80	80.50	70.20
Saline coefficient	4.50	3.5	10.60	8.96	7.54

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In all of these the percentage of sugar is below the standard of 12 per cent adopted by the factories; the Florimond Desprèz and Butteau Desprèz are especially low, having but little more than half the amount required, and a purity coefficient also far below the standard. The Simon Le Grand is also lacking in sugar and purity, and would quickly be rejected at the factory. Of the other two, the Klein Wanzleben has nearly the required sugar content, but the large amount of solid contents reduces its purity below the standard; while the Vilmorin Desprèz, though lower in sugar, has a greater degree of purity.

The large percentage of ash is doubtless due to alkali soil, in which they were planted.

Sugar-beets, from the South California Experiment Station, Chino Ranch, near Pomona. They were planted on the 6th of June, two rows of each kind, 20 inches apart and 30 feet long. The beets were thinned to 4 and 6 inches in the rows. They receive two irrigations, the first and last weeks in July. In October they were dug up and sent to the Central Station; received there in excellent condition, and immediately analyzed, with the following results:

Analyses of Sugar-Beets from the South California Experimental Station.

	Vilmorin White Improved.	Lane's Imperial.	Dippe Klein Wanzleben.	Simon Le Grand.	Florimond Desprèz.	Vilmorin.
Average weight of beets, in grams	250.00	349.00	303.00	365.00	290.00	307.00
Juice.						
Specific gravity	1.0643	1.0583	1.0583	1.0613	1.0678	1.0660
Solid contents, per cent	15.70	14.30	14.30	15.00	16.50	16.10
Cane sugar, per cent	12.24	10.54	10.82	11.48	13.53	12.57
Ash, per cent	0.70	0.81	0.85	0.78	0.90	0.79
Coefficient of purity	77.96	73.77	75.66	76.53	82.00	78.08
Saline coefficient	17.48	13.3	12.73	14.72	15.03	15.91

The Lane's Imperial and Dippe Klein Wanzleben are both below the standards of sugar contents and purity, and would be rejected at the factories. The Simon Le Grand is a little below in sugar, but its high percentage of solid contents reduces its purity coefficient to at least five below the standard.

The Vilmorin White Improved and Vilmorin are each above the standard in sugar, but not quite up to that of purity; while the Florimond stands well in each requirement.

Sugar-beets; sent by J. D. Huffman, of Lodi. One half of the large and small beets taken for analysis. Weight of beets, 635 grams; specific gravity of the juice, 1.064. The solid contents amounted to 15.67 per cent, of which 11.87 per cent was cane sugar and .80 per cent ash. The purity coefficient was therefore 76.09, which places the sample within that required for profitable working.

Sugar-beets; sent by J. DeBarth Shorb, of San Gabriel. The beets weighed 927 grams; the juice had a specific gravity of 1.052. The solid contents amounted to 12.8 per cent, of which 7.46 was cane sugar, thus making the purity coefficient 58.3. The latter is far below the working minimum.

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Sugar-beets; sent by J. C. Merrill, of Los Angeles.

One of the samples, comprising three beets, was sent on August 20th, and at that time they were one hundred and five days old and not ripe. The other two samples or varieties were sent on October 6th, and received on the 9th, in good condition. They were analyzed as soon as received and the following results obtained:

	Sent August 20.	Sent October 6.	
		Klein Wanzleben.	Vilmorin.
Average weight of beets, in grams	866.66	1,110.00	960.00
Juice.			
Specific gravity	1.0727	1.0665	1.0652
Solid contents, per cent	17.65	16.20	15.90
Cane sugar, per cent	11.97	12.42	13.72
Ash, per cent	.50	1.04	.57
Coefficient of purity	67.74	76.66	86.22
Saline coefficient	23.94	11.94	24.07

The first of these samples is too low in sugar content and in purity coefficient to make it acceptable at the factories. Of the other two, the Klein Wanzleben is about the California standard of 12 per cent sugar, but somewhat low in the purity coefficient. The Vilmorin is materially better in both respects, and would doubtless supply a very eligible material if not allowed to attain so large a size. All the samples exceed in weight the standard desired by the factories, which is about a pound only, or an extreme of two pounds.

Sugar-beets, from 5 miles southwest of Tulare; sent by W. F. Stuart. The beets were somewhat dry when received on the 29th of September. The examination resulted as follows:

Average weight, in grams	309.00
Cane sugar in juice, per cent	16.20
Ash of juice, per cent	1.06
Coefficient of purity	75.70
Saline coefficient	15.28

This is a very good showing for a sugar-beet, even though the purity coefficient is rather low; the sugar contents are quite 4 per cent above the minimum required by the factories. The ash is rather high, doubtless because of the alkali in the soil on which the roots were grown, but this would probably cease to be the case after a few years of culture.

Sugar-beets, from Rutherford, Napa County; sent by Charles Thompson. The seeds were obtained from the United States Department of Agriculture. The samples were received in good condition and averaged 850 grams (28.6 ounces) in weight. An examination of the juice gave the following result:

Specific gravity	1.0647
Solid contents, per cent	15.80
Cane sugar, per cent	12.10
Ash, per cent	.94
Coefficient of purity	76.58
Saline coefficient	12.87

This would in Europe be considered a very fair beet for sugar-making, but is not up to the California standard, which at Watsonville and

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Chino is expected to be 12 per cent of sugar. However, these beets were too near the limit of size admitted by the factories, which do not desire any roots above a pound; the smaller (within limits) the richer in sugar.

THE INVESTIGATIONS OF CATTLE FOODS OF CALIFORNIA.

By M. E. Jaffa.

The importance of the analyses of the different fodders and feeding stuffs of this State to the farmers has long been felt by the Station, but the lack of working force and the great pressure of other work has, heretofore, prevented the undertaking of such investigations.

It is the intention of the Station to analyze, not only the cattle foods, but to make complete examinations of all the food materials used by man and the domestic animals.

The great aim of chemical analysis of feeding stuffs in general is to ascertain the amounts of the different nutrients contained in the food; and the object of rational feeding is to use the results so gained in a scientific, practical, and economical manner.

As this is the first report of our State Experiment Station on the subject, it will be proper to give a brief review of the history of such investigations, and an explanation of the terms used.

The first experiments in this direction were made in Germany a little more than twenty years ago, by Bischoff and Voit in Munich, Stohmann and Henneberg in Weende, and Wolff in Hohenheim, and it is due to these men that rational feeding has advanced to the great extent it has in the present day.

The subject was first prominently brought to notice in the United States in an address before the Connecticut Board of Agriculture in 1873, by Prof. W. O. Atwater, now Director of the Storrs School Agricultural Experiment Station, Storrs, Connecticut, the annual reports of which contain most valuable and interesting information, and from which some of the data herein given have been obtained.

In regard to cattle foods the German feeding standards and methods of computing rations are in common use all over the Eastern States, and we trust that it will not be long ere the same will be in vogue here. But owing to the great differences in climate and harvesting conditions between California on the one hand, and the East and Europe on the other, it becomes imperative with us to make complete investigations of all the different food materials as they exist here, in order that we may proceed intelligently with the making up of rations.

While chemical analysis and investigation can do and have done much toward helping and guiding the farmer and dairyman, they can not at the present time accomplish all that could be desired.

Grave errors may arise by following too closely the standards and rations set down by chemical research alone, without taking into account the local circumstances, the individual needs of the animals, and the purposes for which they are fed, whether for milk, for fattening for market, or for work; as well as the variations of the feeding stuffs themselves. Yet, without any knowledge of the composition of the substance fed, the farmer is not only in the dark as to the benefit to be derived

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from the food, but is also ignorant of the actual amount necessary, thus at times wasting considerable valuable material.

Nutritive Ingredients of the Food.—The sustaining of the animal body in all of its varied requirements is done by the *nutritive ingredients*, or nutrients of the food, which comprise protein, fat, carbohydrates, and mineral matters; the latter, in estimating food values, are not considered, not because they are not necessary, but for the reason that nearly all food, no matter of what description, contains a sufficient supply of mineral matter.

When investigating the amount of ingredients withdrawn from the soil by the crops from which the foods are derived, the ash or mineral contents is the all-important part.

Protein, derived from the Greek, signifying "to take first place," contains all the nitrogenous compounds of the food, and consists chiefly of albuminoids, such as the albumen of the egg, the myosin of lean meat, gluten of wheat, casein of milk, the gelatinoids of the bones and tendons, etc. Besides the albuminoids, there are other nitrogenous matters, chief among which is the class termed amides, which are found to a greater or less extent in all foods, more particularly in those of vegetable origin.

"In vegetation the amides appear as intermediate stages between the mineral or inorganic matter, in the shape of ammonia salts and the organic constituents, or albuminoids. They are, on the one hand, formed in the growing plant from the ammonia salts by a constructive process, and from them, or by their aid, probably the albuminoids are built up. On the other hand, in the animal body they are the stages through which the elements of the albuminoids pass in their reversion to purely mineral matter. In germinating seeds and developing buds the amides probably combine both these offices; in being first formed in the germ from the albuminoids in the seeds, entering the young plant or shoot, and in being reconstructed into albuminoids. Their free solubility in water, and their ability to penetrate moist membranes, adapt them for this movement. They temporarily accumulate in the seedlings and buds, but disappear to a great extent as the plant matures, albuminoids taking their places, in which transformation they require the aid of the carbohydrates." (Johnson.)

The amide percentage of the total nitrogen contained in foods varies from less than 1 per cent in some meals, up to as much as 40 per cent in some of the green fodders; and in some varieties of beets used as feeding material, as much as 50 per cent of the total nitrogen is non-albuminoid. The amides are not considered as valuable as the albuminoids in their direct nutritive effect; but they are, similarly to the carbohydrates, conservers of the albuminoids.

The albuminoids in the different food materials are estimated from the nitrogen by multiplying the figure for the latter by 6.25; nitrogen being 16 per cent of the albuminoids. In England the factor used is 6.33.

The nitrogenous compounds of the food are generally, for the above reasons, reported as *crude protein*.

Use of Protein.—The protein being the only nutrient containing nitrogen, has for its principal function the formation of the nitrogenous ingredients of the blood, bone, hair, muscles, skin, tendons, etc., because, as far as is known, no albuminoids are formed in the animal body otherwise than by the transformation of similar bodies presented to it from

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external sources. The protein can be transformed into fats and may serve as fuel.

Fat.—The term "fat" includes the butter of milk, the fat of meats, oil of seeds, wax of plants, etc. It is determined by treating the perfectly dried substance with ether, the extract thus resulting being designated as "crude fat." As might be supposed, these ether extracts have different nutritive values, the fat from the green fodders being of less value than that from the meats and seeds. Some authorities, in estimating the nutritive effect of food, give to all the fats the same significance. The use of fat is mainly as a fuel supply, although it may form fatty tissue but not muscle.

Carbohydrates.—The carbohydrates, commonly called "nitrogen-free extract," on account of their containing no nitrogen, are starch, sugars, gums, and woody fiber; the latter, in the statement of the analyses of cattle foods, is reported separately, while the remainder of the above are, in order to conform to the general usage, classed together under the head of "Nitrogen-free Extract." The gums play only a secondary part as regards the nutritive value of foods. The carbohydrates are transformed in the body into fats, and consumed as fuel. The latest experimental evidence goes to prove that the protein, carbohydrates, and fat may, directly or indirectly, be transformed into the fats of milk.

Ash.—The mineral matters, or ash, of the food materials consist chiefly of lime, potash, and phosphoric acid, with varying amounts of sodium, magnesia, iron, sulphuric acid, chlorine, silica, etc. These ingredients have important functions to perform in the animal body, and, as previously stated, exist in sufficient quantities in all foods.

Digestibility of Feeding Stuffs.—The chemical composition of the food material alone is not of much value to the farmer if he does not know how much of each nutrient for the feeding stuff in question is digestible. In all foods there is always a certain portion of each nutrient which is not digested in its passage through the body. In order to ascertain how much is indigestible, the food is weighed and analyzed before consumption, and the weight and composition of the animal excrement is also determined. The difference between the two analyses is taken as the quantity digested. The results so obtained are only approximate, but in the present state of such researches, the best data available. They are termed *digestion coefficients.*

To illustrate the above: In every 100 pounds of the alfalfa hay analyzed there are 7.96 pounds of crude protein, 1.40 pounds of crude fat, 35.12 pounds of crude fiber, and 38.28 pounds of nitrogen-free extract. For this hay it has been found that of the protein about 75 per cent is digestible, of the fat 48 per cent, of the crude fiber 46 per cent, and about 68 per cent of the nitrogen-free extract can be digested. Hence, in 100 pounds of the alfalfa there would be 5.97 pounds of digestible protein, 0.67 pounds of digestible fat, 26.03 pounds of digestible nitrogen (free extract), 16.15 pounds of digestible fiber; the last two are carbohydrates. In a similar manner are obtained the results given in the table below.

For each food material the digestion coefficients vary to some extent. For instance, while about 57 per cent of the protein is digestible in oat hay, 78 per cent is so in the case of wheat middlings or bran.

Nutritive Ratio.—The nutritive ratio is the proportion between the digestible protein, or nitrogenous matters of the food, and the non-nitrogenous part, or the fats and carbohydrates. Thus, in alfalfa—

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The digestible protein is	5.97
The digestible fat×2.5 is	1.68
The digestible fiber is	16.15
The digestible nitrogen (free extract) is	26.08
	43.86

43.86 divided by 5.97 gives 7.3, which is the nutritive ratio.

In determining this ratio, the figure denoting the quantity of digestible fat is multiplied by 2½, because it has been ascertained by experiment that about two and one half times as much heat is supplied in a pound of fat as in the same quantity of carbohydrates.

Feeding Standards and Rations.—A feeding standard is the amount of food required per day by the different classes of animals. A ration is the quantity of food consumed in twenty-four hours. The *standards* commonly in use in this country are the ones set down by the German investigators in this subject; notably, Dr. E. Wolff, by whom the following table has been worked out:

(Pounds to be fed per day per 1,000 pounds live weight.)

	Total Organic or Dry Matter.	Protein.	Carbohydrates.	Fat.	Nutritive Ratio.
Horse, at light work	21.0	1.5	9.5	.40	1:7.0
Horse, at average work	22.5	1.8	11.2	.68	1:7.0
Horse, at hard work	25.5	2.8	13.4	.80	1:5.5
Oxen, fattening, first period	27.0	2.5	15.0	.50	1:6.5
Oxen, fattening, second period	26.0	3.0	14.8	.70	1:5.5
Oxen, fattening, third period	25.0	2.7	14.8	.60	1:6.0
Milch cows	24.0	2.5	12.5	.40	1:5.4
Sheep, wool-producing (coarser breeds)	20.0	1.2	10.3	.20	1:9.0
Sheep, wool-producing (finer breeds)	22.5	1.5	11.4	.25	1:8.0
Sheep, fattening, first period	26.0	3.0	15.2	.50	1:5.5
Sheep, fattening, second period	25.0	3.5	14.4	.60	1:4.5
Swine, fattening, first period	36.0	5.0	27.5		1:5.5
Swine, fattening, second period	31.0	4.0	24.0		1:6.0
Swine, fattening, third period	23.5	2.7	17.5		1:6.5

The estimation of rations from the above table is a simple matter, but this, and a discussion thereof, will have to be deferred until we have a greater number and more complete set of analyses of California food materials upon which to base our calculations.

Potential Energy.—The measure of food as regards its fuel value is made in terms of "potential energy," the unit of which is the *calorie*, or the amount of heat necessary to raise the temperature of a kilogram of water 1° Centigrade, or one pound of water 4° Fahrenheit. Instead of this unit we may use a unit of mechanical energy, the foot-ton, which is the force that would lift one ton one foot, one calorie being equal to about 1.53 foot-tons.

Recent experiments have been made with animals in the respiratory apparatus to learn the proportions in which the several classes of nutrients replace each other as fuel for the body. At the same time experiments have been made with the calorimeter to determine the heats of combustion of the same materials. The results so obtained agreed very well with those from the direct experiment with the respiratory apparatus, and they also proved that the different nutrients replaced each other according to their ascertained heats of combustion.

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Professor Rubner found, in experiments made in the physiological laboratory at Munich, the quantities of materials which were equal to 100 of fat to be as follows:

Nutritive Substances, Water Free.	As determined by direct experiment with Animals.	As determined by Calorimeter.
Myosin	225	213
Lean meat	243	235
Starch	232	229
Cane sugar	234	235
Grape sugar	256	235

Taking the ordinary food materials as they come, the following general estimate has been made for the average amount of energy in one gram of each of the classes of nutrients:

Potential Energy in Nutrients of Food.

	Calories.	Foot-Tons.
In one gram protein	4.1	6.3
In one gram fats	9.3	14.2
In one gram carbohydrates	4.1	6.3

These figures mean that when a gram of fat is consumed, be it fat of the food or body fat, it will, if its potential energy be all transformed into heat, yield enough to warm 9.3 kilograms of water 1° Centigrade, or if it be transformed into mechanical energy, such as the muscles use to do their work, it will furnish as much as would raise one ton 14.2 feet, or 14.2 tons one foot. The potential energy of the protein or carbohydrates is less than one half that of the fat. These figures, as stated by Professor Atwater, are not absolutely accurate, and may be revised by future research in the subject.

The potential energy is very simply calculated by the use of the above figures. The amount digestible of each of the nutrients is ascertained thus: For each gram of protein so found there will be 4.1 calories of potential energy; similarly for carbohydrates, and for each gram of fat, 9.3 calories. A much more convenient mode of calculating the potential energy is to estimate it for the pound of the food used. This is done by supposing each per cent of each nutrient to represent 0.01 of a pound, which is equivalent to 4.53 grams. Hence, in 0.01 pound of protein or carbohydrates there will be 18.6 calories (4.53×4.1); 0.01 pound of fat will yield 42.2 calories (4.53×9.3).

Let us apply these figures to the sample of alfalfa, which contains 5.97 per cent of digestible protein, 0.67 of fat, and 42.18 of carbohydrates. The potential energy for the protein in one pound would be 111.04 calories (5.97×18.6). For the carbohydrates 784.55, and the fat in one pound would yield 28.27 calories (42.2×0.67); the total potential energy in one pound amounting to 923.86 calories.

The use of the above data gives a means of simplifying the calculations of the rations when the sum of the calories and the necessary

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amount of protein are known. The fat and carbohydrates can replace each other to some extent in any ration; that is, one may be increased and the other diminished, provided the sum of the calories of potential energy remains constant.

CALIFORNIA FEEDING STUFFS.

In the table below are given the results of the analyses of California cattle foods so far obtained, and also, for the purpose of comparison, the analyses of some of the same food materials taken from Bulletin No. 21 of the Agricultural Experiment Station of Indiana.

All of the samples of California fodders examined, with the exceptions of the *Lathyrus sylvestris*, which was grown on the University grounds, and the two specimens of wild hay from the land of Mr. J. W. Shanklin, Lassen County, were sent by Mr. W. P. A. Brewer, of San Mateo.

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Composition of the Fodders.

	Original Substance.											
	Percentage Composition.						Amount Digestible in 100 Pounds.				Potential Energy in One Pound (Calories)	Nutritive Ratio
	Moisture.	Pure Ash.	Crude Protein.	Crude Fiber.	Nitrogen-free Extract.	Crude Fat.	Crude Protein.	Crude Fat.	Crude Fiber.	Nitrogen-free Extract.		
Green Fodders.												
Lathyrus sylvestris (Cal.)	63.48	3.18	8.18	9.76	13.77	1.63	6.23	.98	5.27	8.94	422	1:2.4
Lathyrus sylvestris (England)	58.63	3.09	7.44	12.21	16.58	2.05	5.65	1.23	6.59	10.78	480	1:3.6
Hays.												
Lathyrus sylvestris hay	10.00	7.83	20.16	24.05	33.94	4.02	15.32	2.41	13.94	22.06	1,070	1:2.7
Oat hay (Cal.)	10.38	6.75	8.31	23.85	47.91	2.80	4.74	1.34	13.83	29.70	954	1:9.9
Oat hay (Cal.)	9.80	7.24	6.57	25.75	48.54	2.10	3.74	1.00	14.93	30.09	949	1:12.7
Oat hay (Eastern)	9.15	6.45	8.85	28.07	44.71	2.74	5.04	1.32	16.28	27.72	968	1:9.4
Alfalfa hay (Cal.)	12.18	5.06	7.96	35.12	38.28	1.40	5.97	.67	16.15	26.03	925	1:7.3
Alfalfa hay (Eastern)	8.37	6.88	11.03	25.84	46.24	1.64	8.29	.64	11.11	30.06	947	1:5.2
Wild hay (Eleocharis palustris), (Cal.)	11.55	7.66	5.69	22.27	51.18	2.65	2.89	1.06	11.36	31.73	900	1:15.7
Wild hay (Atropis Californica), (Cal.)	10.10	6.82	5.30	27.34	48.44	2.00	2.65	.80	13.94	30.03	901	1:17.3
Bur-clover hay (Cal.)	11.25	6.91	10.50	26.19	44.92	2.23	5.99	1.29	11.79	27.90	942	1:7.1
Miscellaneous.												
Wheat middlings (Cal.)	11.29	4.01	18.33	5.55	55.77	5.05	14.29	3.48	1.39	42.94	1,231	1:3.7
Wheat middlings (Cal.)	12.36	3.14	14.43	4.15	61.80	4.12	11.26	2.84	1.04	47.58	1,262	1:4.3
Wheat middlings (Eastern), average of 28 analyses	11.88	3.16	15.05	4.32	61.67	3.91	11.75	2.70	1.08	47.49	1,238	1:4.7
Wheat bran (Cal.)	11.06	6.42	15.49	8.57	54.21	4.25	12.42	2.93	2.14	41.74	1,169	1:4.1
Wheat bran (Cal.)	11.97	6.44	12.77	9.28	55.49	4.05	9.96	2.79	2.32	42.72	1,141	1:5.2
Wheat bran (Eastern), average of 66 analyses	12.52	5.68	15.02	9.31	53.94	3.53	11.72	2.44	2.33	41.53	1,138	1:4.7
Linseed meal, old process (Cal.)	9.35	5.22	29.75	6.23	31.20	18.25	24.39	16.61	1.25	22.77	1,670	1:2.7
Linseed meal, old process (Eastern), average of 22 analyses	9.51	5.53	31.65	10.51	35.20	7.59	25.95	6.91	2.10	25.70	1,291	1:1.7

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In Bulletin No. 99, just issued, the green fodder *Lathyrus sylvestris* was fully described. It differs slightly in composition from the sample grown and analyzed in England, in that it has more protein, but less fat and nitrogen-free extract than are found in the English specimen; this being due, in all probability, as has been stated, to the different stages at which the plants were cut. It is a very valuable forage plant, and a better appreciation of its nutritive value will be had by comparing it, in the form of hay, with the first quality oat hay. It will be seen from the table that it contains 20.16 per cent of crude protein, which is about two and one half times as much as is found in the oat hay. The crude-fat percentage is also much higher, as indicated by the figures 4.02, as against 2.80 for the oat hay. An inspection of the amounts digestible in the two foods renders the contrast still more striking, for the reason that in the vetches, to which the *Lathyrus sylvestris* (flat pea) belongs, the digestion coefficients of protein and fat are greater than in the case of oat hay.

There are in every hundred pounds of the *Lathyrus sylvestris* 15.32 pounds digestible protein, being more than three times the amount (4.74 pounds) contained in every hundred pounds of oat hay. The digestible fat (2.41) is nearly double that (1.34) for the oat hay. The nutritive ratio is very much closer than that of the oat hay. In the *Lathyrus sylvestris* there is one part of digestible protein or albuminoids for every 2.7 parts of non-nitrogenous matters, while in the oat hay there is only one part protein for every 9.9 parts of non-nitrogenous.

A comparison of the analyses of the first quality oat hay grown here with that from the East, shows a close agreement as regards the ash, the portein, and the fat; the ash percentages of which are 6.75 for California and 6.48 for the Eastern sample, the protein percentages 8.31 and 8.85, respectively, while for the fat the figures are 2.80 as found here and 2.74 for the Eastern specimen. The same general agreement is seen in the nutritive ratio and potential energy of the two hays.

As might be supposed, the second quality, containing as it does more straw, will naturally have less protein and fat and more crude fiber than the first quality—the percentages being, respectively, for the protein, 8.31 and 6.57; for fat, 2.80 and 2.10; for fiber, 23.85 and 25.75.

We must defer making comparisons of California alfalfa with that grown elsewhere until we have more analyses at hand, because the samples analyzed consisted entirely of stems, and hence would contain much less protein and fat and show a far higher percentage of crude fiber than would a representative sample. It is to be regretted that it was not possible to analyze another specimen in time for this publication.

The bur-clover hay, with its 10.50 per cent of crude protein and 2.23 of fat, constitutes a very fair fodder.

The wild hays, *Eleocharis palustris* and *Atropis Californica*, from Lassen County, contain very low percentages of protein, 5.69 and 5.30, respectively; but an average amount of fat, 2.65 and 2.00 representing the amounts found. The nutritive ratios, 15.7 and 17.3, are far from what is desirable.

A case of marked agreement is shown between the analyses of the second sample of wheat middlings and the average of twenty-two analyses of the same food material as it exists elsewhere, as indicated by the following figures:

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	For California.	For the Average.
Protein	14.43	15.05
Fat	4.12	3.91
Nitrogen-free extract	61.80	61.67
Crude fiber	4.15	4.32
Ash	3.14	3.16

The first sample of wheat middlings has a greater nutritive value, in that it contains more protein and fat, although a somewhat less amount of carbohydrates. A comparison of the analyses of bran shows greater variations than were found in the case of the middlings; still the differences are not very pronounced.

The average of sixty-six analyses of bran made elsewhere shows 15.02 per cent protein, 3.53 per cent fat, 9.31 per cent crude fiber, 53.94 per cent nitrogen-free extract, and 5.68 per cent ash. The average of the analyses of the two samples of California bran gives, for protein, 14.13 per cent; for fat, 4.15 per cent; for crude fiber, 8.93 per cent; for nitrogen-free extract, 54.85 per cent; and for ash, 6.43 per cent. It will be thus seen that the bran is slightly lower in protein contents, but somewhat higher as regards the fat.

The exceedingly high per cent of crude fat in the linseed meal is owing to the oil not having been completely extracted. The figure for the fat, 18.25, given in the table, is nearly two and one half times the amount (7.59) found as an average for the percentage of fat in twenty-two analyses, as taken from the Indiana bulletin. The quantity of crude fiber, 6.23 per cent, contained in the California sample, is much lower than that (10.51) found in the above named average. The ash and protein do not differ materially.

It will thus be seen that so far as examined, where representative samples have been used, the California products compare very favorably with those of the Eastern States.

SULPHURING IN FRUIT DRYING.

By E. W. Hilgard.

Of late several papers in this State have discussed the subject of the use of the sulphuring process in fruit drying, some prefacing their articles with the remark that I had "issued another proclamation" on the subject. I am unable to remember having uttered anything in public relating to the subject since the publication of Bulletin No. 86, eighteen months ago. Since, however, the articles alluded to bring the matter forward, and imply a partial misconception of my views, and of their true basis, I think it proper to put them on record once more.

Sulphurous gas, which is formed when sulphur is burned, is well known, and constantly used as a disinfecting, bleaching, and deodorizing agent, second in virtue only to chlorine. The fact that it is the agent officially used in the disinfection of infected houses, ships, and individuals is conclusive on these points. It is therefore idle to pretend that sulphuring does not diminish the flavor of fruit, or of anything else touched by it. It is perfectly certain that it does so; and the

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only debatable question is the extent to which it may be used for bleaching fruit without any material detriment to the flavor.

It is in evidence that a reasonable amount of bleaching can be done by applying the gas to the freshly cut fruit without injuring the flavor to a material degree, since the flavor will penetrate from the inside outward to a sufficient extent to compensate for the loss of what naturally belongs to the bleached exterior portion.

The limit, however, is a narrow one, and it is so frequently exceeded in practice (whether intentionally to secure "extra light" color to attract the unwary purchaser, or, more commonly, by unskillful or negligent workmen in charge of the sulphuring boxes) as to put upon the market a good deal of fruit that is the reverse of creditable to the State that produces it, and ill-calculated to insure a permanent demand. This is especially true of the thinly sliced apples and pears, which are quickly penetrated by the gas, and assume a greenish-white tint, that, while it may be inviting to equally "green" purchasers, assures the expert that the natural flavor is practically gone. The producer himself declines to put them on his table, but the dealer and the public, as at present informed, are willing to pay an extra price for it. This demand for unnaturally light-colored dried fruit is a "fad" like many others, which will have its day, but will inevitably give way in the course of time to a preference for the better flavored product having the tint which insures its being so. So long as the "fad" lasts, so long will producers or dealers sulphur the fruit to suit the eye rather than the palate of the consumer. It certainly seems desirable to hasten the advent of a more rational state of the public mind on this point; quite apart from the sanitary consideration, which, if not of primary importance as regards most of the sulphured fruit now in the market, has, nevertheless, proved sufficiently potent to cause the practice of sulphuring to be legally prohibited in the old world, where, therefore, our fruits so treated would fall under the ban of the law. An additional consideration is that this process permits of rendering third and fourth class fruit equal in appearance to the best, and is therefore easily used for fraudulent purposes.

There thus seems to me to be abundant cause for desiring and working for the abatement of the public delusion on the subject of light-colored dried fruit, which sacrifices the substance to the shadow, and is certain in the end to inure to the detriment of our dried fruit trade. The oversensitiveness that has of late manifested itself in respect to the maintenance of my position in the question seems, therefore, to be ill-founded.

I hope to find a measurably unobjectionable substitute for the uncertain process as now practiced, in the use of a solution of "bisulphite of soda" (heretofore sold under the name of "California fruit salt") of definite strength, into which the cut fruit can be dipped before drying. In this process, the same agent (sulphurous gas) is employed in the liquid form, but so controlled as to the amount used that the chances of overdoing the sulphuring—now so great because of the convenience with which the fruit can be left exposed to the sulphurous gas for an indefinite time—would be reduced to a minimum. The compound can be produced very cheaply, and the solution used will be very weak.

The exact strength and time required to produce the best results with different fruits will form the subject of experiments at the Station during the coming fruit season.

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VI. FERTILIZERS, GYPSUM, ETC.

Sewerage products; sent by Thomas Lewis, of Sacramento. The two samples comprised earths charged with the sewage of the city. "The mass comes from house vaults and cesspools of the city, and is dumped in a pile and left standing for two or three months. It is then sifted and baked, and afterward pulverized; then it is ready for the market."

Sample No. 1 burns with heavy fumes, and contains 38 per cent of volatile matter. Heated with lime, ammonia is evolved.

Sample No. 2 is more earthy; gives off very little fumes when burnt; contains only a trace of ammonia.

The analyses of the two samples resulted as follows:

	No. 1.	No. 2.
Phosphoric acid	2.05	0.21
Potash	.43	Very little.
Nitrogen	1.61	
Nitrogen as ammonia	1.96	

Sample No. 1 is a fair fertilizer, and worth about $8 per ton. The other is not worth the expense of hauling.

Bat manure, obtained from a cave in the mountains of New Mexico; sent by C. P. Grogan, of Riverside, Cal. A light loose mass, with the following constituents:

Organic matter	64.97
Carbonate of lime	28.17
Phosphoric acid	4.36
Sand and insoluble matter	2.50
	100.00

There is probably a fair percentage of nitrogen.

Bat manure, from the Germain Fruit Company, of Los Angeles. The sample is very similar to the above in appearance as well as in composition, as shown in the following analysis:

Organic matter	66.25
Carbonate of lime	23.29
Phosphoric acid	4.36
Sand and insoluble matter	6.10
	100.00

Phosphatic guano, four samples, from an island in the Pacific Ocean, near Honolulu; furnished by Williams, Dimond & Co., of San Francisco.

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	No. 1.	No. 2.	No. 6.	No. 7.
Total volatile matter—water, carbonic acid, and organic matter, etc.	23.49	18.43	25.12	25.35
The air-dried substance contains—				
Moisture	5.74	8.35	11.24	6.90
Nitrogen—				
Nitrogen as ammonia (ready formed)	None.	None.	None.	None.
Nitrogen as nitrates	.33	Traces.	.70	Traces.
Nitrogen, organic	.92	.41	.59	.31
Total nitrogen found	1.25	.41	1.29	.31
Total nitrogen calculated as ammonia	1.51	.49	1.56	.37
Phosphoric acid—				
Soluble	1.00	.16	.96	.11
Reverted	14.52	3.49	6.79	3.67
Insoluble	22.17	24.44	22.68	17.88
Total phosphoric acid	37.69	28.09	30.43	21.66
Available phosphoric acid	15.52	3.65	7.75	3.78
Potash (K_2O)	.90	.64	.29	.22

Nos. 1, 2, and 6 grade as high-class phosphates, and No. 7 is "good." No. 1, considering its large proportion of available phosphoric acid and total nitrogen, is good enough as it is and need hardly be manipulated; with the addition of a little Chile saltpeter, it is what orange growers would want. The others would of course be greatly improved by treatment with sulphuric acid, but if ground fine and made uniform, would rate in effectiveness with bone-meal, even as they are.

Guano, from an island off the coast of Lower California, about 600 miles south of San Diego; sent by Dr. T. C. Stockton, of San Diego. An analysis of the sample shows the following composition:

Moisture		11.62
Nitrogen as ready formed ammonia	2.60	
Nitrogen, organic, 4.42; calculated as ammonia	5.37	
Total nitrogen calculated as ammonia		7.97
Phosphoric acid, soluble	2.62	
Phosphoric acid, insoluble	11.27	
Total phosphoric acid		13.89
Potash (K_2O)		1.65

The above falls a little below Peruvian guano in percentage composition, but is still an excellent fertilizer. The free ammonia should be preserved from waste by mixing the guano with gypsum.

Guano, from an island south of San Diego; the island is a resort for sea fowls and a seal rookery; sent by H. M. Stanton, of San Diego. An analysis showed the following composition:

Moisture		22.06
Nitrogen as ammonia ready formed	3.26	
Nitrogen, organic, 4.37; calculated as ammonia	5.32	
Total nitrogen calculated as ammonia		8.58
Phosphoric acid, soluble	4.02	
Phosphoric acid, insoluble	11.18	
Total phosphoric acid		15.20
Potash (K_2O)		2.86

The above is equal to the well-known Peruvian guano in percentages of nitrogen and phosphoric acid, but falls a little behind it in potash. The waste of ammonia, which exists in the free state, should be prevented by application of finely ground gypsum.

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Fish guano; sent by Allen & Lewis, of San Francisco. An analysis shows it to contain 21.50 per cent of moisture and 1.38 per cent of free ammonia.

The very moist condition of the guano causes it to lose very much ammonia and to deteriorate very rapidly. It should be mixed with finely ground gypsum and dried.

Dissolved bones, from the Germain Fruit Company, of Los Angeles. An examination for phosphoric acid alone gave the following result: Soluble in water, 4.2 per cent; insoluble, 10.1 per cent; total phosphoric acid, 14.3 per cent.

GYPSUM.

The value of gypsum as an antidote to alkali in the lands of this and adjoining States is being recognized so fully that quite a demand for it has sprung up; and with this demand a search for new deposits and for a commercial article of special purity. Many specimens have therefore been sent in for examination, many of which contained no gypsum whatever, others a small percentage, and still others were of a high degree of purity.

Gypsum; surface specimen from west side of Tulare County; sent by Julius Forrer, Foreman of Experiment Station. The specimen is quite impure, from its surface exposure to soil and dust, and on analysis shows the presence of 52.2 per cent of insoluble matter (sand, clay, etc.) and 47.8 of gypsum. It is more than probable that in the body of the bed, when opened up, a purer material will be found.

Gypsum, taken from the lands of the San Joaquin Valley Coal Mining Company, near Coalinga, Fresno County; sent by Mr. Louis Einstein, of Fresno. The sample is in the usual commercial powdered form, and has the following composition:

Gypsum	88.8
Insoluble matter	2.2
Carbonate of lime	9.0
	100.0

Gypsum; commercial sample of the Nevada Gypsum and Fertilizing Company; sent from Fresno by John S. Dore. The sample is in the form of a fine white powder, which, on analysis, was found to contain 80.5 per cent of gypsum, 1.19 per cent of insoluble matter, and 18.3 per cent of carbonate of lime.

Gypsum; bought for the Tulare Experiment Station. No. 1, from the Nevada Gypsum and Fertilizing Company; No. 2, from the Bakersfield Mine. Both specimens were in the form of white powder, as usually furnished to the market. An analysis of each gave the following results:

	Nevada G. & F. Co.	Bakersfield Mine.
Gypsum	88.9	83.2
Insoluble matter	1.4	4.8
Carbonate of lime	9.7	12.0
	100.0	100.0

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Gypsum; commercial sample of the Ventura Crystal Plaster Company, sold by Donahue, Emmons & Co.; sent from Fresno by Harry Thomas, for examination. The sample is of a buff gray color, and shows, on handling, considerable coarse material. On wetting it becomes somewhat plastic, and has a clayey smell. On examination it was found to contain 65.8 per cent of gypsum, 22.5 of insoluble matter, and 11.7 per cent of other matters. The insoluble residue contains fragments of brown iron ore and clay shale.

Gypsum; commercial sample from Southern California, and sold in Fresno by Messrs. Holmes & Co.; sent for examination as to its purity. The sample is of a buff gray color, and in powder form. An analysis shows the composition to be:

Gypsum	72.0
Insoluble matter	14.3
Carbonate of lime	3.9
Other matters	9.8
	100.0

Gypseous sand, from Huron, Tulare County; sent by Mr. Rickard, of Berkeley. The sample contains 22 per cent of gypsum, the remainder being chiefly sand. It is therefore suitable for only local use.

Granular gypsum; three specimens from Huron, Tulare County; sent by Messrs. Schwinn & Ballou. Two of the samples of gypsum are highly mixed with blackish clay, and of small value. The third is quite a pure specimen of gypsum, containing 96 per cent, with only 4 per cent of impurities. The locality of occurrence was not given.

Gypseous clay, three samples, sent by Mr. Percy Morgan, of Berkeley. No. 1 is a mixture of gypsum and clay, in the proportion of 27.5 of the former to 72.5 of the latter. No. 2 is chiefly infusorial earth, with a little gypsum. No. 3 is only carbonate of lime. The materials are of no real value.

Gypsum; commercial sample from the Centaur Mine, Ventura County; sent from Fresno, for examination. A whitish powder, which was found to contain 83.2 per cent of gypsum, 8.6 per cent of sand, and 8.2 per cent of other impurities.

Gypsum, from the foothills near Harold, in the edge of Antelope Valley, 65 miles north of Los Angeles; sent by J. A. Clark, of Los Angeles. This is a very pure specimen; on solution it leaves less than 1 per cent (0.73) of insoluble matter.

Gypsum, from Lovelocks, Nevada; sent by the Nevada Gypsum and Fertilizing Company, of San Francisco. A white powder. Its composition proved to be 99.85 per cent of gypsum and 0.15 per cent of sand.

Gypsum, from Bakersfield; sent by Mr. C. Morgan, of Berkeley. There were four samples in the lot sent for examination, all small. These embrace calcite crystals from Keene Station, 30 miles from Bakersfield; a small piece of selenite, taken from a mine at Carisa Plains, in the hills on the line of Kern and San Luis Obispo Counties, 48 miles from Bakersfield; a piece of shaly claystone with a seam of gypsum, from the Sunset District, 40 miles from Bakersfield, in Section 13; and a sample of whitish gypsum, in the Sunset District, Section 38. An analysis of the latter shows 63.8 per cent of gypsum and 36.2 per cent of impurities.

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Gypsum; sent by B. McCreary, of Sacramento. A fine white powder, chiefly of gypsum, with a small per cent of magnesia.

Gypsum; sent by J. A. Lytle, of Sumner. The sample is quite calcareous and has the following composition: Insoluble matter, 2.90 per cent; carbonate of lime, etc., 14.26 per cent; gypsum, 82.84 per cent. Another sample from the same party, said to be "soft material from the bottom of the bed, 3 feet thick," contained 80.79 per cent of gypsum.

Gypsum, from the Kern County Land Company, of Bakersfield. Three specimens sent. One of these is a pure selenite. Another is selenite, which by exposure to the weather has been changed to a soft, whitish, and rather floury gypsum with only 3.71 per cent of water. The other sample is a very impure gypsum. The weathered selenite, richest of all, has been thrown aside at the mine, as worthless.

Gypsum; sent by S. W. Morgan, of San Diego. No. 1 is a light-colored sample, obtained from San Francisco. No. 2 is a dark sample, ground in Los Angeles; the original locality is not known. They have, respectively, the following composition:

	No. 1.	No. 2.
Gypsum	87.0	72.0
Insoluble matter (sand, etc.)	13.0	6.0
Carbonate of lime	.....	22.0
	100.0	100.0

Sample No. 2, from Los Angeles, is the more impure of the two, and is quite calcareous in character.

Gypsum, from Lovelocks, Nevada; sent by the Nevada Gypsum Company, of San Francisco. A whitish pulverulent mass that covers the surface of the gypsum deposit, and was supposed to be worthless. It, however, is found to be composed largely of gypsum, and is valuable as an application to soils. The examination showed:

Gypsum	93.69
Carbonate of lime	4.89
Sand, etc.	1.42
	100.00

Gypsum; sent by the Alpine Plaster and Cement Company, of Los Angeles. A fine white powder, containing 7.64 per cent of sand and other insoluble matter.

Gypsum, from San Benito County; sent by Messrs. Wooster & Ensign, of San José. This is almost pure gypsum, and in solid mass.

Gypsum; sent by the Ventura Asphalt Company. The specimen contains but 21.25 per cent of gypsum, the remainder being chiefly made up of infusorial earth. Except perhaps for use in the immediate neighborhood of the deposit, this impure gypsum is of but little value.

Gypseous material, from J. S. Drury, of Bakersfield. Four small specimens were sent, each to be examined for alumina. No. 1, on examination, proved to be sulphate of alumina. No. 2 is an impure gypsum. No. 3 is a mixture of Glauber's salt (sulphate of soda) and

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gypsum. No. 4 is alunite and kaolinite, with the following composition: Silicic acid, 9.08; alumina, 47.97; potash, 8.57.

Gypsum; sent by A. Mooney, of Lemoore, Tulare County. The specimen was examined by Mr. H. C. Hyde, a student in the laboratory, with the following result:

Gypsum	66.20
Potash	1.24
Sand and other insoluble matter	10.78
Iron oxide	11.13
Alumina	.77
Soda	.84
Magnesia	.21
Water, etc.	8.83
	100.00

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II.

REPORTS

ON

CULTURE WORK AT THE EXPERIMENT STATIONS.

A. *Central Station;* Alameda County.
B. *Foothill Station;* Amador County.
C. *Southern Coast Range Station;* San Luis Obispo County.
D. *San Joaquin Valley Station;* Tulare County.
E. *South California Station;* Los Angeles County.

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REPORTS ON CULTURE WORK AT THE SEVERAL EXPERIMENT STATIONS.

A. CENTRAL EXPERIMENT STATION.

Berkeley, Alameda County.

REPORT ON FIELD WORK AT CENTRAL STATION.

By EMIL KELLNER.

Field Culture.—The following culture work has been carried on during the year: The field work consisted in sowing again the general collection of cereals, wheat, rye, barley, and oats. Experiments with the Hessian fly were continued.

The plots adjoining the Economic Garden and near the western entrance of the grounds have been fertilized with dissolved guano, donated by the Mexican Phosphate and Sulphur Company, H. M. Newhall, agents, San Francisco. The amount used was at the rate of 500 pounds per acre. The grain grew finely, and in spite of a dry season produced good grain. The cost of fertilization with this class "D," would be $7 50 per acre, freight to be added.

A sufficient amount of hay has been raised to feed the Station team. The team has been employed during the summer and fall months in hauling manure from the town. The soil being exhausted, it is impossible to raise anything without fertilization.

The orchard has been partly fertilized with animal manure, dissolved guano, and plaster; the dissolved guano acted very promptly, producing fine fruit. The soil being very shallow in the orchard, causes the early decay of a great many trees.

The nursery has been started to renew the orchard, or to start a new orchard with young trees, which will be differently trained, on another piece of land. A great many valuable varieties of pears are in the orchard and must be saved.

The garden of economic plants has been carried on as usual, furnishing fiber plants and raw material to the parties in this State interested in the culture of ramie, flax, and other fiber plants. The garden is an interesting place for the students in botany. The students of the College of Pharmacy have been coming over in a body from San Francisco frequently with their Professor in Botany, to listen to lectures given to them and to see different plants valuable in medical practice.

The necessity for a new propagating house is daily becoming more apparent.

A large number of English oaks have been raised for distribution. Experiments with Louisiana sugar cane and cassava root have resulted in a failure, the climate at Berkeley being too cool for semi-tropical plants.

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The olives imported from Italy have grown finely; the crop of olives is this year a complete failure, on account of coulure (dropping of fruit after a cold spell).

The Italian and Persian grapevines have been propagated, so that the Station will be able to distribute a large number of vines to those who desire these varieties.

A large number of eucalyptus trees of different varieties have been planted on the north and eastern boundary, but the season being dry they were a failure.

Practical instruction has been given to a few students in horticulture, at the propagating houses, and in the nursery during the spring months.

Report on Grains; Crop of 1892.

Wheat.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Arnold's Gold Medal	Jan. 13	July 2	Poor growth; rust confined to leaf; 3 feet high.	
Austrian	Jan. 13	July 14	Poor growth; 2½ feet high.	Badly infested.
Arizona Indian Seed	Jan. 13	July 13	2½ feet high; no rust.	A few flies.
Archer's Prolific	Jan. 13	July 13	Rust; bearded.	Hessian fly bad.
No. 1, Australian (Adelaide Hackett)	Jan. 13	July 14	Rust on leaf and stalk; 6 feet high.	None.
Australian (Hackett's No. 2)	Jan. 13	July 14	Rust on leaf and stalk; 6 feet high; fine growth.	None.
Black Emmer	Jan. 13	July 13	Rust; bearded.	Some Hes'n fly.
Bearded Club	Jan. 13	July 13	Rust; bearded; a fine wheat; 4½ feet high.	Hessian fly bad.
Black Bearded	Jan. 13	July 23	Aphis and rust; 5½ feet high.	No Hessian fly.
Blue Bearded	Jan. 13	July 23	Rust; 4 feet high.	Hessian fly bad.
Beardless Club	Jan. 13	Aug. 6	Rust; 3 feet high.	Hessian fly bad.
Big Long-Bearded Club	Jan. 13	July 13	No rust; 3½ feet high; bearded; very good.	None.
Beardless Velvet	Jan. 13	July 13	4 feet high; failure.	
Blue Glass	Jan. 13	July 13	No rust; bearded; 4½ feet high.	None.
Bohemian	Jan. 13	Aug. 6	2 feet high; a poor crop.	Infested badly.
Big White Club	Jan. 13	Aug. 13	4½ feet high; rust on leaf and stalk; beardless.	None.
Big Long-Bearded Club	Jan. 13	July 14	4½ feet high; no rust.	None.
Bearded, from Missoyen	Jan. 13	July 23	4 feet high; bearded; rust on leaf; extra good.	None.
Blood Red	Jan. 13	Aug. 6	Rust; poor growth; 3½ feet high.	Badly infested.
Black Centennial	Jan. 13	July 29	Rust; 5½ feet high.	A few.
Currel's Prolific Winter	Jan. 13	July 29	Rust; failure; 3½ feet high.	
Champlain	Jan. 13	July 29	Rust; 4½ feet high.	None.
Cujarian	Jan. 13	July 25	Rust; fine growth; 5½ feet high.	None.
Common March	Jan. 13	July 23	Rust; fine growth; 5 feet high.	None.
California Spring	Jan. 13	July 23	Rust; fine growth; good; 4½ feet high.	A few.
Clawson	Jan. 13	July 23	Rust; fine growth; 5 feet high.	Badly infested.
Chiddam	Jan. 13	Aug. 6	Rust; poor growth; 3 feet high.	Badly infested.
Centennial Black-Bearded	Jan. 13	July 29	Rust; fine growth; 6 feet high.	None.
Chile	Jan. 13	Aug. 6	Rust; failure; 4½ feet high.	Hessian fly bad.
Carter's Anglo-Canadian	Jan. 13	Aug. 6	Rust; poor growth; sowed too late; bearded; 4½ feet high.	Badly infested.

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WHEAT—Continued.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Carter's Miller's Delight	Jan. 13	Aug. 6	Rust; fair growth; 4 feet high.	A few flies.
Carter's Queen	Jan. 13	Aug. 6	Rust; 4 feet high.	A few flies.
Carter's Prince of Wales	Jan. 13	Aug. 6	Rust; fine growth; 4½ feet high.	A few flies.
Carter's Standup	Jan. 13	Aug. 6	Rust; poor growth; 3 feet high.	Badly infested.
Carter's Pearl	Jan. 13	Aug. 6	Rust; poor growth; 3 feet high.	A few flies.
Carter's Holborn Wonder	Jan. 13	Aug. 6	Rust; poor growth; 3 feet high.	Badly infested.
Carter's Pride of the Market	Jan. 13	Aug. 6	Rust; poor growth; 3 feet high.	Badly infested.
Carter's Bird-proof	Jan. 13	Aug. 6	Rust; poor growth; 3½ feet high.	A few flies.
Carter's Flour Ball	Jan. 13	Aug. 6	Rust; fair growth; 4 feet high.	A few flies.
Carter's Hundred-fold	Jan. 13	Aug. 6	Rust; poor growth; 3 feet high.	Badly infested.
Carter's Earliest of All	Jan. 13	July 19	Rust; fair growth; 5 feet high.	A few flies.
Diehl Mediterranean Winter	Jan. 13	Aug. 6	Rust; fair growth; 4½ feet high.	A few flies.
Diamond	Jan. 13	July 14	Rust; fair growth; bearded; 5 feet high.	None.
Defiance	Jan. 13	July 23	Rust; fair growth; 5 feet high.	None.
Extra Early Oakley Winter	Jan. 13	July 14	Rust; fair growth; 4½ feet high.	None.
Egyptian Imported	Jan. 13	July 14	Rust on leaf and stalk; fair growth; 5½ feet high.	None.
Emmer	Jan. 13	July 23	Rust; fine growth; 6 feet high.	None.
Egyptian	Jan. 13	July 18	Rust on stalk and leaf; 6 feet high; bearded; fine growth.	None.
Early Clawson	Jan. 13	Aug. 6	Rust on leaf and stalk; 4½ feet high; fine growth.	None.
Frankensteiner	Jan. 13	July 23	Rust on stalk and leaf; 5 feet high; fine growth.	None.
Forelle	Jan. 13	July 14	Rust on leaf; 5 feet high.	None.
Fultz	Jan. 13	July 23	Rust on leaf and stalk; fine growth.	None.
Fern, or April	Jan. 13	July 29	Rust on leaf and stalk; fair growth.	A few flies.
F. Gates	Jan. 13	June 27	No rust; 3½ feet high.	None.
Four-rowed Sheriff (imptd.)	.....	Aug. 6	Rust on leaf; poor growth.	Badly infested.
Fulcaster Winter	Jan. 13	July 29	Rust on leaf and stalk; 5 feet high; fair growth.	None.
Greek Atlanti	Jan. 13	July 23	Rust on leaf; fair growth; 5½ feet high.	None.
Ghika, or Odessa	Jan. 13	July 18	Rust on leaf; 5½ feet high; poor growth.	None.
Genoese Winter	Jan. 13	July 14	Rust on stalk and leaf; 4½ feet high; fair growth.	None.
Hallett's Original (winter)	Jan. 13	Aug. 6	Rust on stalk and leaf; 4 feet high; poor growth.	Badly infested.
Hallett's Genealogical	Jan. 13	Aug. 6	Rust on stalk and leaf; 4 feet high.	Badly infested.
Hallett's Pedigree (White Victoria)	Jan. 13	July 23	Rust on stalk and leaf; 4 feet high; fair growth.	Badly infested.
Harris, from Jasper	Jan. 13	July 14	Rust on stalk and leaf; 5 feet high.	None.
Hybrid Llama	Jan. 13	July 23	Rust on leaf and stalk; 2½ feet high; poor growth.	Badly infested.

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WHEAT—Continued.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Hungarian (Brenner)	Jan. 13	July 23	Rust on stalk and leaf; 4½ feet high.	A few flies.
Hybrid Dattel	Jan. 13	July 29	Rust on leaf and stalk; 3 feet high; poor growth.	A few flies.
Hungarian Mountain	Jan. 13	July 23	Rust on leaf; 4½ feet high; fair growth.	A few flies.
Hungarian, from Burke	Jan. 13	July 23	Rust on leaf and stalk; 4½ feet high; fair growth.	Badly infested.
Hunter's White	Jan. 13	July 18	Rust on leaf; 5½ feet high; fair growth.	A few flies.
Indian (three months)	Jan. 13	July 18	Slight rust; 5½ feet high; fair growth.	None.
Improved Rice Winter	Jan. 13	July 14	Rust on leaf and stalk; 5½ feet high; fair growth.	None.
Improved Circassian	Jan. 13	July 18	Rust on leaf; 5 feet high.	Badly infested.
Indian Winter	Jan. 13	July 18	Rust on leaf and stalk; poor growth; 4 feet high.	A few flies.
Jonquil	Jan. 13	July 18	Rust on leaf and stalk; 3 feet high; poor growth.	A few flies.
Little Club	Jan. 13	July 23	Rust on leaf and stalk; 3 feet high; poor growth.	Badly infested.
Mammoth	Jan. 13	July 14	Rust on leaf and stalk; poor growth; 4½ feet high.	None.
Martin's Amber	Jan. 13	Aug. 6	Rust on leaf and stalk; poor growth; 3½ feet high.	A few flies.
Manchester	Jan. 13	July 14	Rust on leaf and stalk; poor growth; 4½ feet high.	A few flies.
Mold's White Winter	Jan. 13	July 23	Rust on leaf and stalk; 4½ feet high; fair growth.	A few flies.
Mold's Red Winter	Jan. 13	July 23	Rust on leaf; poor growth.	Badly infested.
Michigan Mixed	Jan. 13	July 23	Rust on leaf and stalk; 5 feet high.	None.
McGeehe's White Winter	Jan. 13	July 18	Rust on leaf and stalk; 5 feet high; fair growth.	None.
Missoyen	Jan. 13	July 14	No rust; 5 feet high; fine growth.	None.
North Allerton	Jan. 13	Aug. 6	Rust on leaf and stalk; poor growth; 4½ feet high.	Badly infested.
Nonpareil	Jan. 13	July 18	Rust on leaf and stalk; 5 feet high; fair growth.	None.
Nonette Lausanne	Jan. 13	July 18	Rust on leaf and stalk; 4½ feet high; fair growth.	None.
Nicaragua (E. K. Carr, Texas)	Jan. 13	July 14	No rust; 5 feet high; fair growth.	None.
Oregon Big White Club	Jan. 13	July 14	Rust on leaf; 4½ feet high; fair growth.	None.
Paine's Defiance	Jan. 13	Aug. 6	Rust on leaf; 5 feet high; fine growth.	A few flies.
Palestine	Jan. 13	July 14	Rust on leaf; small straw; poor growth; 3½ feet high.	None.
Propo	Jan. 13	July 14	Rust on leaf and stalk; 4½ feet high; fair growth.	A few flies.
Probsteier	Jan. 13	July 25	Rust on leaf and stalk; 5 feet high; fair growth.	None.
Polish	Jan. 13	July 18	Rust on leaf and stalk; 5 feet high; fine growth.	None.
Proper	Jan. 13	July 14	Rust on leaf; 4½ feet high; fair growth.	None.

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WHEAT—Continued.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Petali	Jan. 13	July 14	Rust on leaf; 4 feet high; poor growth.	None.
Pringle's Best	Jan. 13	July 25	Rust on leaf and stalk; 5 feet high; fine growth.	None.
Pringle's Defiance	Jan. 13	July 25	Rust on leaf; 5 feet high; fine growth.	A few flies.
Patent Office	Jan. 13	July 25	Rust on leaf and stalk; 6 feet high; fine growth.	None.
Red Club Hedgehog	Jan. 13	July 25	Rust on leaf and stalk; 5 feet high; fine growth.	None.
Red Chaff	Jan. 13	July 29	Rust on leaf and stalk; 6 feet high; fine growth.	A few flies.
Red Bearded	Jan. 13	July 25	Rust on leaf and stalk; 5½ feet high; fine growth.	None.
Russian Durmur Wheat	.....	.....	No rust; 6 feet high; fine growth.	None.
Red Wheat Goldfinder	Jan. 13	Aug. 6	Rust on leaf and stalk; 5 feet high; fine growth.	A few flies.
Raub's Black Prolific	Jan. 13	Aug. 6	Rust on leaf and stalk; 5 feet high.	None.
Rye Wheat	Jan. 13	July 29	Rust on leaf and stalk; 6 feet high; fine growth.	A few flies.
Russian Red Bearded (Hessian fly-proof)	Jan. 13	July 18	No rust; 6 feet high; fine growth.	A few flies.
Royal Australian	Jan. 13	July 18	Rust on leaf and stalk; 5¼ feet high; fine growth.	None.
Red Sonora	Jan. 13	June 26	No rust; 4 feet high; fine growth.	None.
Red Sea	Jan. 13	July 14	Rust on leaf and stalk; 5 feet high; fine growth.	None.
Rust-proof, from India	Jan. 13	July 19	Rust on leaf and stalk; poor growth; 2 feet high.	No flies.
Libby's No. 1	Jan. 13	Aug. 6	Rust on leaf and stalk; 4 feet high; poor growth.	A few flies.
Sicilian	Jan. 13	July 19	No rust; 5 feet high; fine growth.	No Hessian fly.
Snowflake	Jan. 13	July 25	Rust on leaf and stalk; 4½ feet high; fair growth.	None.
Smogge	Jan. 13	Aug. 6	Rust on leaf; 3½ feet high; poor growth.	Badly infested.
Siberian	Jan. 13	Aug. 6	Rust on leaf; 4½ feet high; fair growth.	A few flies.
Solid Straw Poulard	Jan. 13	July 19	No rust; 3½ feet high; fair growth.	None.
Square Sicilian	Jan. 13	July 19	Rust on leaf; 5 feet high; fair growth.	A few flies.
Thuringian	Jan. 13	Aug. 6	Rust on leaf and stalk; 5 feet high; fine growth.	A few flies.
Taganrog	Jan. 13	July 30	Rust on leaf; 6 feet high; fair growth.	None.
Tunisian	Jan. 13	July 30	Rust on leaf; 6 feet high.	None.
Touzelle	Jan. 13	July 25	Rust on leaf; 4½ feet high; fine growth.	Badly infested.
Victor	Jan. 13	July 25	Rust on leaf; 4½ feet high; fair growth.	None.
Victoria	Jan. 13	July 25	Rust on leaf and stalk; 5 feet high; fair growth.	None.
Volo	Jan. 13	July 14	Rust on leaf and stalk; 5½ feet high; fine growth.	None.
Velvet Club	Jan. 13	July 25	Rust on leaf and stalk; 5 feet high; fair growth.	A few flies.
Winter Raub's Black Prolific	Jan. 13	Aug. 6	Rust on leaf and stalk; 4½ feet high.	Badly infested.
Winter Fulcaster	Jan. 13	July 25	Rust on leaf and stalk; 5½ feet high; fine growth.	None.

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WHEAT—Continued.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
White Russian	Jan. 13	Aug. 6	Rust on leaf and stalk; 4 feet high; poor growth.	Badly infested.
White Genoese	Jan. 13	July 25	Rust on leaf and stalk; 4½ feet high; fair growth.	A few flies.
White Sonora	Jan. 13	July 19	Rust on leaf and stalk; 5½ feet high; fair growth.	Badly infested.
White Banater	Jan. 13	July 25	Rust on leaf and stalk; 5½ feet high; fair growth.	A few flies.
Winter Eagle	Jan. 13	July 25	Rust on leaf and stalk; 5½ feet high; fair growth.	A few flies.
Winter	Jan. 13	July 25	A little rust on leaf and stalk; 6½ feet high; fine growth.	A few flies.
Whittington	Jan. 13	July 14	Rust on leaf and stalk; 4½ feet high; fair growth.	Badly infested.
White Llama	Jan. 13	July 25	Rust on leaf; 4 feet high; fair growth.	Badly infested.
White Essex	Jan. 13	Aug. 6	Rust on leaf; 3½ feet high; poor growth.	Badly infested.
White Club	Jan. 13	July 14	Rust on leaf and stalk; 4½ feet high.	None.
White Flanders	Jan. 13	Aug. 6	Rust on leaf and stalk; 3½ feet high; poor growth.	Badly infested.
White Pearl	Jan. 13	July 18	Rust on leaf and stalk; 4½ feet high; fair growth.	A few flies.
White Crimea	Jan. 13	July 14	Clean; 4½ feet high; fair growth.	None.
Washington Glass	Jan. 13	.....	A failure.	
Yellow Noe	Jan. 13	.....	Rust on leaf and stalk; 3½ feet high; fair growth.	A few flies.

OATS.

The oats were remarkably free from rust.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Brown Jeanette	Feb. 3	Aug. 1	3¾ feet high	None.
Bald Oats	Feb. 3	July 20	3½ feet high	None.
Black, from Brille	Feb. 3	July 1	3½ feet high	None.
Black Champion	Feb. 3	July 1	4 feet high	None.
Black Tartar	Feb. 3	July 1	4 feet high	None.
Black, from Choulmiers	Feb. 3	July 1	3½ feet high	None.
Canadian	Feb. 3	July 12	4½ feet high	None.
Early, from Etampes	Feb. 3	July 19	3 feet high	None.
Early, from Georgia	Feb. 3	July 20	3 feet high	None.
Early August	Feb. 3	July 19	4 feet high	None.
From E. R. Carr, Texas	Feb. 3	July 7	3½ feet high; fine oats	None.
Harris, from Alabama	Feb. 3	July 7	3½ feet high	None.
Gray, from Houdan	Feb. 3	July 19	4½ feet high	None.
Gray Winter	Feb. 3	July 19	3 feet high	None.
Hungarian	Feb. 3	Aug. 1	4½ feet high	None.
Hallet's Pedigree (Black Tartar)	Feb. 3	July 19	3½ feet high	None.
Hallet's Pedigree (White Canadian)	Feb. 3	July 12	4½ feet high	None.
Hopeton	Feb. 3	July 12	5½ feet high	None.
Heavy Winter	Feb. 3	July 19	4½ feet high	None.
Late Silesian	Feb. 3	July 20	5½ feet high	None.

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OATS—Continued.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Late Siberian	Feb. 3	July 12	3½ feet high	None.
Longfellow	Feb. 3	Aug. 1	4½ feet high	None.
Large Naked	Feb. 3	Aug. 1	4 feet high	None.
Ligovo	Feb. 3	Aug. 20	5½ feet high	None.
Mox Rust Proof	Feb. 3	July 7	4½ feet high; slight rust.	None.
New Black Champion	Feb. 3	Aug. 1	4½ feet high	None.
Podolian	Feb. 3	July 20	5 feet high	None.
Probsteier	Jan. 22	July 16	4½ feet high	None.
Polish	Feb. 3	July 20	5 feet high	None.
Scotch Hopeton	Feb. 3	July 12	5 feet high	None.
Surprise	Feb. 3	July 12	5 feet high	None.
Small Pied de Mouche	Feb. 3	July 20	4½ feet high	None.
Thuringian	Feb. 3	July 20	4½ feet high	None.
Two-rowed Scotch	Feb. 3	July 12	3½ feet high	None.
Two-rowed Skin-lip	Feb. 3	July 7	3½ feet high	None.
Welcome	Feb. 3	July 20	5 feet high	None.
White Flanders	Feb. 3	July 20	5 feet high	None.
White Bolognese	Feb. 3	July 20	4½ feet high	None.
White Australian	Feb. 3	Aug. 1	4 feet high	None.
Yellow Flanders	Feb. 3	Aug. 1	4 feet high	None.
Yellow August	Feb. 3	Aug. 1	4 feet high	None.

RYE.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Excelsior	Jan. 14	July 19	5½ feet high; fair growth.	None.
Hungarian	Jan. 14	July 19	6 feet high; fair growth.	None.
Perennial	Jan. 14	July 18	6½ feet high; fair growth.	None.
Perennial Gascon	Jan. 14	July 19	6 feet high; leaf rust; fair growth.	None.
Swedish Sand	Jan. 14	July 30	6 feet high; leaf rust; fair growth.	None.
St. John's Day	Jan. 14	July 19	6 feet high; leaf rust; fair growth.	None.
Spanish Double	Jan. 14	July 19	6½ feet high; leaf rust; fair growth.	None.

SPELT.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Beardless White	.....	Aug. 6	Rust on leaf; poor growth; 3 feet high.	Badly infested.
Black Emmer	.....	Aug. 6	Rust on leaf; fair growth; 5 feet high.	Badly infested.
Blue Bearded	.....	July 30	Rust on leaf; fair growth; 5½ feet high.	None.
March Emmer	.....	July 30	Rust on leaf; 5 feet high; fair growth.	None.
Red Emmer	.....	July 30	Clean; 5 feet high; fair growth.	A few flies.
Silesian	.....	July 25	Rust on leaf; 5 feet high; fair growth.	A few flies.
White Bearded	.....	July 30	Rust on leaf; 5½ feet high; fair growth.	A few flies.
White Silesian	.....	July 25	Rust on leaf; 4½ feet high; fair growth.	None.
White Emmer	.....	July 25	Rust on leaf; 5½ feet high; poor growth.	Badly infested.
White Bearded	.....	July 20	Rust on leaf; 4½ feet high; poor growth.	Badly infested.

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BARLEY.

Variety.	When Sown.	When Ripe.	Remarks.	Remarks on Hessian Fly.
	1892.	1892.		
Annate Scotch	Feb. 3	July 7	3 feet high	None.
Black Spring	Feb. 3	July 7	3½ feet high	None.
Black, two-rowed	Feb. 3	July 7	2½ feet high	None.
Blue, six-rowed	Feb. 3	July 12	3 feet high	None.
Bluish Naked	Feb. 3	July 12	3 feet high	None.
Black two-rowed Earliest	Feb. 3	July 7	3 feet high	None.
Berkeley Hybrid, two-rowed	Jan. 13	.....	4 feet high; fertilized with guano.	None.
Berkeley Hybrid, two-rowed	Feb. 3	July 12	3 feet high; without fertilizer.	None.
Berkeley-Hybrid, six rowed	Feb. 3	July 12	3 feet high	A few flies.
Chevalier	Feb. 3	July 12	3½ feet high	None.
Carter's Prolific	Feb. 3	July 12	3 feet high	None.
Earliest Black	Feb. 3	July 7	2½ feet high	None.
Erfurt	Feb. 3	July 19	2½ feet high	A few flies.
Frick's Drought Proof	Feb. 3	July 19	3 feet high	A few flies.
Four-rowed Spring	Feb. 3	July 19	3½ feet high	None.
Himalaya	Feb. 3	July 7	2½ feet high	None.
Hallett's Pedigree Chevalier	Feb. 3	July 20	3 feet high	None.
Italian	Feb. 3	July 20	3 feet high	None.
Imperial	Feb. 3	July 12	3 feet high	None.
Kalina	Feb. 3	July 12	3 feet high	None.
Large Naked, two-rowed	Feb. 3	July 12	2½ feet high	None.
Manchurian	Feb. 3	July 7	3 feet high	None.
Nepaul	Feb. 3	July 7	2½ feet high; beardless	None.
Palestine	Feb. 3	July 20	3 feet high	None.
Peacock	Feb. 3	July 20	3 feet high	None.
Rice, or Sprat	Feb. 3	July 20	2½ feet high	A few flies.
Small Blue Naked	Feb. 3	July 20	3½ feet high	A few flies.
Small White Naked	Feb. 3	July 20	3½ feet high	None.
Scotch, two-rowed	Feb. 3	July 20	3 feet high	None.
Six-rowed Brenner	Feb. 3	July 20	2½ feet high	A few flies.
Six-rowed Winter	Feb. 3	July 12	3 feet high	A few flies.
Six-rowed Erfurt	Feb. 3	July 12	3 feet high	None.
Thuringian	Feb. 3	July 12	2½ feet high	A few flies.
Two-rowed	Feb. 3	July 12	3 feet high	None.
Two-rowed Skin-lip	.....	July 7	3½ feet high	A few flies.
White Australian	.....	July 12	3 feet high	None.

THE AFRICAN DATE PALM.

By C. H. SHINN.

In the previous report, that of 1890, mention was made of the importation of date palms, which had been planted at the Station. This importation was inadvertently alluded to as Persian. A letter from Prof. H. E. Van Deman, Pomologist of the Agricultural Department at Washington, corrected this mistake. Some varieties were from Egypt; others from Algeria. Some additional information is given by Professor Van Deman's letters, and as they also illustrate the care taken in the Department to avoid distributing dangerous insects, I quote at some length. In an early letter he says:

"The first lot was composed of nine trees—three trees of each kind—and came from Biskra, Algeria. They arrived at Philadelphia on July 4, 1890, and at this Department on the 9th. They are five or six years old, and were taken from the ground where they had been planted by the Arabs (the outer leaves having been cut off about 3 or 4 feet from the ground), and then planted in a box of earth. They are

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in excellent condition, but a new scale insect was found on them. We are keeping them here in order to destroy these insects by a treatment of kerosene emulsion. The second lot arrived at Philadelphia from Cairo, in Egypt. There are fifty-four in this lot, all planted in tubs, and in excellent condition.

"There are six trees of eight of the choicest varieties known in Egypt, and six male trees. They have been gathered from different parts of the country, and were intended for the British colony of Mauritius, but that government decided not to take them, and our Consul-General at Cairo bought them for the trifling sum of $200. These trees are infected with a scale insect, and they will be kept here until the pests are killed. It will perhaps be early in September, 1890, before we consider them safe to ship west. There is in all about a carload, and we will endeavor to have them watered en route so that they may reach their different destinations in as good a condition as they are now.

"I have also ordered plants from the region of the Euphrates and Tigris Rivers, through our Consul at Beyrout, and also another collection of the choicest varieties of Persia, through our Minister at Teheran. These will, perhaps, be received within a year."

The specimens alluded to were received in fair condition. They were planted at the South California Station, in the Chino Valley, and at the San Joaquin Station, near Tulare City. The larger number of varieties and, in some respects the best plants, were sent to Tulare, as it was thought at Washington that the climate there would prove more favorable. This expectation does not seemlikely to be realized, as several varieties that are more tender than others have suffered this winter. Some, however, are eminently suited to the place.

At both Stations the pistillate or bearing palms are planted in a circle, with the staminate plant in the center. The soil is sandy and free from alkali. Irrigation ceased the first of September. Deglet Nour and M'Kintichi prove to be very poor growers, with small leaves, and hard to root, and not to be recommended unless the fruit is of peculiar excellence.

The Sultaneh variety, said to be one of the best, is extremely delicate in appearance, leaflets slender and fine, growth slow; suffers from frost at Tulare. This variety does better in the Chino Valley, and is certainly one of the most beautiful of all in an ornamental sense.

Amhat, at Tulare, is so badly frosted that it will be advisable to move it to a better locality. When most of the large leaves of a palm are killed, and protection is needed for the heart of the plant, it is evident that no valuable result can follow further experiment at that point. This variety in the Chino district has so far escaped with only slight injury. It is the most tender of all the Persian palms at the Stations.

Next to the Amhat is Haraneh, a poor grower, considerably frosted at Tulare, and slightly so in Southern California.

Rashedah and Rass show only medium hardiness at Tulare, losing a portion of the upper leaves. Rass is a remarkable variety of very strong growth; leaves large, light green, and beautiful in appearance. The plant at Tulare has already six small suckers. It is the only one of all the palms that has as yet increased itself by division. The difference in rapidity of growth between such varieties as Rass and such as Sultaneh or Deglet Nour, is as great as that between a Bartlett pear tree and a Seckel.

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One palm at Tulare shows marked hardiness. This is Seevah, a compact grower, with small, dark leaves; it is more hardy than the seedling date palms at the Station, which latter correspond more nearly in hardiness with such varieties as Rass. In Seevah we probably have a date palm suitable to all parts of the San Joaquin Valley; perhaps three or four more of the twelve varieties represented are likely to prove desirable there. But several, as the preceding notes imply, are not likely to withstand the frosts of the open valley, whatever they may do on the foothills. Referring again to the seedling date palms at Tulare Station for comparison, one observes that all are slightly frosted, while two are badly so. The wild date (*P. Canariensis*) would undoubtedly stand the same locality and pass unscathed through the severest winter ever known there, but this species of date is merely ornamental; and the seedling date offers no advantages in point of hardiness over any, except a few of the named varieties now at the Station, while it is distinctly at a disadvantage in comparison with several of the best.

A curious fact in connection with the date palms is that the large grasshoppers of the San Joaquin Valley attack the leaves with a special zeal. In 1891 the grasshoppers left fields of grain, and beds of small cultures representing many species of plants, to settle on the palms and eat holes in the leaves. They could hardly be prevented from destroying several varieties for which they showed a strong preference, and they injured nearly all to some extent. Their method of attack is to make dozens of holes, about as large as a dime, in the leaflets. Sultaneh, Rass, and Haraneh are among those that were the most severely injured. Thriftiness, or lack of thriftiness, in the plant seemed to make little or no difference with the grasshoppers. The hardy variety, Seevah, they left entirely alone, and it was the only one that escaped attack. At the South California Station, also, the grasshoppers left other plants to attack the palms, and here, as at Tulare, they showed preferences, though less marked, as their invasion was of much shorter duration. During the past summer, 1892, they have continued to work upon the trees at Tulare, though not so much as before. In the Chino Valley they have not injured the palms, and it is probable that the trouble is over in that region.

There has not been any complaint, so far as I know, that the grasshoppers destroy seedling date palms, or the Canarian date, in any part of California. At the Stations, as it happens, the seedling palms were uninjured, though this was probably owing to their location nearer the buildings than were the named varieties. It is well known that the locusts of the deserts of Asia and Africa sometimes entirely destroy palm groves, but it is certainly surprising to find that the California grasshoppers prefer the hard, fibrous leaves of the palm to any other green food.

The latest importation of palms was the famous Fard variety, from Arabia. This appeared to be well rooted, but it has not survived the very hot and dry summer, though all the palms received an abundant supply of water. It can hardly be expected that every plant brought such a long distance can be successfully grown. The Syrian dates have not yet arrived. They will probably be placed at the South California Station. Mr. Frank Kimball, at National City, San Diego County, received a number of the imported African dates, and as he has a

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peculiarly mild climate to deal with, it may be expected that they will thrive there.

The season of 1892 has not produced much change in the aspect of any of the palms at the Stations. They have grown fairly well in all cases, except where noted. The observations in the preceding notes continue to hold good. It should be said, in fairness, that the cold of the winter of 1891 was very severe, and may not occur again for a generation. Oranges were destroyed in some of the citrus colonies that have hitherto escaped with little or no injury, and the financial loss in many districts was very great. Everything looks favorable for the ultimate establishment of the date palm in some portions of California.

If the question be asked, Where can the date palm be planted with reasonable prospect of success? the answer is, that while the hardiness of some varieties is greater than was supposed, it will not be wise to plant for a crop in any except the hotter parts of the State. Oroville, Vacaville, Winters, all the hot foothills comparatively free from frost, are suited to this tree, provided sufficient water is supplied, for the date palm requires much moisture. "Its feet in a spring and its head in the tropic sun" paraphrases the Arab theory about this wonderful tree. It would probably grow marvelously well in the oases of the Colorado Desert, or in the famous Palm Valley of San Diego County, where there are large groves of the native desert palm (*Washingtonia filifera*).

The problems of importance, next to the hardiness of different varieties, seem to be: How soon will the plants bear, and how fast can they be propagated by suckers? When better established it will be possible to force them into a more rapid division, but this can only be done at the expense of the mother plants. The small number of specimens obtained by the Stations (only two of any variety, and of some only one) precludes the idea of such an early or general distribution as many correspondents appear to expect. Besides, the United States Agricultural Department has distinctly required the first increase of stock to be held subject to its orders, at least for the present. Those variet es that promise best can be imported by nurserymen in large numbers, and easily propagated to supply any future demand. The experiment at the Agricultural Stations fulfills its end, and justifies the cost, whenever those Stations have fully tested and reported upon the varieties in their hands.

THE FIG IN CALIFORNIA.

By C. H. Shinn.

The fig promises to become one of the most important fruit trees of California. A great deal has been written about it; innumerable importations of varieties have been made by nurserymen and others; large orchards have been planted for table use, drying, canning, and preserving. Still there is much confusion concerning varieties, as a visit to any horticultural exhibit will show, and the whole subject of fig culture seems to be in a condition of change and development.

The outdoor commercial culture of the fig on a large scale belongs so exclusively to the borders of the Mediterranean, especially Asia Minor, that much less is known here about varieties and their treatment than is the case with the more common deciduous fruits, or even with the

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long-cultivated citrus fruits. It is true that the fig is grown as a wall fruit, or in houses, and to a high degree of perfection even in Scotland, and that many writers have discussed these departments of its culture. But Californians wish to plant extensive orchards, and to introduce the fig to the modern American world, as we have already introduced our prunes and our raisins. The widespread interest in the subject is amply proved by numerous papers and discussions in the various horticultural societies and public journals.

When the Experiment Stations were established it was decided to stock them with every distinct variety of fig, and to observe the growth, hardiness, quality of fruit, and other elements of interest. In carrying out this plan about sixty varieties have been collected, and a number of others are growing in nursery rows for future planting. The following list shows the varieties now in orchard form, and, with a few exceptions, large enough to bear fruit:

Agen.	Dalmatian.	Royal Vineyard.
Angelique.	Doreé Narbus.	Ronde Noire.
Abondance precoce.	De Constantine.	Ronde Violette Hâtive.
Brianzola.	Du Roi.	Raby Castle.
Black Ischia.	White Dattato.	Rocardi.
Brunswick.	Black Dattato.	Rubrado.
Black Bourjassotte.	Early Violet.	Smyrna No. 1.
Bourjassotte Grise.	Guigliono.	Smyrna No. 2.
Black Marseilles.	Grossale.	Smyrna No. 3.
Barnasotte Grise.	Gros Gris Bifère.	Smyrna, Wild.
Brown Ischia.	Grizzly Bourjassotte.	San Pedro.
Brown Turkey.	Hirtu du Japon.	Sanvito.
Black Brogiatto.	Ladora.	Trojano.
White Brogiatto.	Monaca Bianca.	White Bourjassotte.
California Black.	Negro Larga.	White Genoa.
Col di Signora Nero.	Osborne Prolific.	White Adriatic.
Drap d'Or.	Pasteliere.	White Marseilles.

Comparative Hardiness.—The first season after the figs were planted at the different Stations, many differences in growth and in adaptation to climate began to be noticed. The varieties showed a greater range of variation in respect to their power to resist cold than any other semi-tropic fruit. The problem that naturally presented itself was this: How do the various sorts compare in point of hardiness and relative endurance? The colder districts of the State desire to grow figs, if possible, and need the varieties that are most hardy. Then, also, we may expect to produce still more hardy seedlings from hybrids of certain sorts, or by fertilizing the finer table figs with the wild Smyrna. In a few more years, when all the varieties being grown are in bearing, the comparative value of the fruits can be better tested.

FIGS AT THE SAN JOAQUIN STATION.

On December 17 and 18, 1891, I examined the growth of the fig trees at the San Joaquin Valley Station, at Tulare. The fig trees here are planted in avenue form, and in the present unsheltered condition of the Station it cannot be said that there is any difference in temperature between different portions of the avenue. In the course of time, when the orchard is fully developed, the avenue will be less exposed to the wind. But the Tulare region is subject to as great a range of temperature as any other part of the San Joaquin Valley. There seems to be a basin about the lake into which the cold air settles, and it is doubtful

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whether rows of forest trees will be of as much service here as in some other localities where the cold is due to air currents that may be broken.

The fig trees at this Station were mostly planted in the winter of 1888–89. Some died, having been set in alkali spots, and were replaced. The worst situations have now been treated with gypsum, about 10 pounds having been put around each tree. Owing to the differences of soil, a very great difference in the growth of trees of the same age is manifest. This of course is complicated with the difference naturally belonging to the growth of different varieties.

All the fig trees received some irrigation, but not a drop of water was allowed them after August. The first heavy frosts in November took off all the leaves. The wood appeared well ripened in most cases, except, as usual, the extreme tips of "water sprouts" and late growths. It was therefore a surprise to the Foreman when some of the trees showed the effects of the early December frosts (temperature 22°). Certain varieties appear to suffer, and it does not seem to be a question of alkali or cold currents, for, as previously stated, the whole tract is subject to identical conditions in this regard; besides, trees of the same kind, one of which stands on sandy soil and the other on "alkali," seem to suffer to a similar extent.

Of the older varieties (older in point of introduction to this State), the California Black is not to be ranked as high in the matter of hardiness as was to be expected. It can only be called "medium;" the White Ischia stands somewhat better; the Dalmatian does fairly well; the Black and White Marseilles, which unfortunately are rather small for table use or for drying, do even better than the Dalmatian. The San Pedro, a fine table variety much liked by growers, suffers greatly, even branches of half an inch thickness being frozen. The two imported Smyrna varieties have stood the frost well. The Brown Ischia has suffered more than the Black California. Three of the Bourjassottes, black, green, and white, together with the White Adriatic, are able to withstand the cold.

Among the newer varieties the Du Roi is one of the most hardy. Ladora, an excellent fig, is badly frosted, but not enough to justify discarding as yet. Col di Signora Nero is so much frozen that it was cut back entirely to the ground.

One of the worst cases in the avenue is that of the Gros Gris Bifere, which is certainly not hardy enough for the Station. Ronde Violette Hâtive is a fine fig, but slightly frosted, and probably safe when older. De Constantine and Drap d'Or have done well. Abondance Precoce suffers a little; Royal Vineyard ranks but medium. The most hardy fig at the Station, and the only one that shows no sign of frost anywhere, is the Doreé Narbus, one of the new importations. There are two trees of this variety in different parts of the grounds, one in alkali, the other (near the orange trees) in sandy soil. It has compact growth, hard, dark bark, short joints, and small buds. The leaves are dark, and rather small.

To sum up these observations, there are two or three sorts being tested that seem unlikely to stand the climate. Possibly ten sorts show appreciable loss of young wood. All the others, except the Doreé Narbus, show some slight effect of frost upon the soft, late growth, but not, except as above noted, enough to affect their orchard value to the region.

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FIGS IN SOUTHERN CALIFORNIA.

The fig experiment at the South California Station, in Chino Valley, is less advanced than any other, since trees were planted there only in the spring of 1891. It was hoped that all the varieties would prove hardy, and, at first, it appeared that they would do so, but in December, 1891, and January, 1892, many varieties suffered from frost. A complete comparison with the other Stations cannot yet be made, for the list of varieties is not yet complete; but the following sorts proved hardy during that severe cold when the thermometer fell to 21° F. at Riverside: Du Roi, Monaca Bianca, Hirtu du Japon, Agen, and Col di Signora Nero. This shows that all, or nearly all of the varieties of the Station list of fifty-one kinds, will thrive in the Pomona and Chino districts. Twelve varieties, mostly new, and very small trees with immature wood, sent to the Station for growth for a year in nursery rows, were severely frozen, in some cases "nearly to the ground." This, however, is not evidence against future success with many of these varieties. The following trees suffered from frost, and are, perhaps, unreliable in that part of the valley: Grosse Grise Bifere, Grizzly Bourjassotte, Ronde Violette Hâtive, and Negro Larga. During the summer of 1892, the recovery of the trees that suffered most severely has been very gratifying, and the healthfulness of White Adriatic orchards in the region confirms the belief that many of the finer figs are especially adapted to the Station. It is less frosty two or three miles from the Station tract, nearer the hills.

FIGS IN THE UPPER SALINAS VALLEY.

At the Southern Coast Range Station, near Paso Robles, where the same varieties of figs are growing as at Tulare, the problem is further complicated by the fact that there is much difference in the soil and location of the trees, the avenue passing through a low swale that is much more frosty, and has a more compact soil, than the rest of the tract. Most of the trees were planted at the same time as those at the Tulare Station. They received no irrigation. Those in the most exposed positions were wrapped in straw to protect them. January 4, 1891, the straw was taken off, so as to make a thorough examination, and put back again.

Among the figs on the high land were the Black and the White Bourjassottes, the two varieties of Smyrna, Ronde Noire, Brunswick, Col di Signora Nero, Angelique, White Ischia, Agen, and Pasteliere. All did fairly well, except the White Ischia, which was badly frosted. At Tulare, also, the White Ischia was more tender than the Bourjassottes. The only marked difference between the two Stations in this group was in the case of Col di Signora Nero, which nearly escaped frost at Paso Robles, but was very badly frosted at Tulare.

Continuing along the avenue toward the swale, under less favorable conditions, White Adriatic, as at Tulare, proved fairly hardy, and grew well. A small tree planted in 1890–91 suffered somewhat. The Dalmatian was only a little touched with frost. Drap d'Or, on quite low ground, suffered much. De Constantine, as at Tulare, made a strong growth, and nearly escaped frost. A Smyrna, planted in the swale in 1890, gave an opportunity for comparison; it was considerably frosted, but not nearly as much as some other varieties. The Black Marseilles,

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which did well at Tulare, was "cut right down" to the ground with the cold. California Black, as at Tulare, was not in the front rank; it is only "of medium hardiness." Brown Ischia, as at Tulare, must be placed before the Black California. Early Violet, which did fairly well at Tulare, was severely frosted here. Doreé Narbus, the most hardy of all at Tulare, "withstood the frost," though in one of the lowest and most exposed situations, but "has grown little." Hirtu du Japon was also hardy. Grosse Grise Bifere, which was one of the most badly frosted sorts at Tulare, was also very severely frosted here. So was the San Pedro and the Monaca Bianca. The last three were on adobe soil.

The Foreman, Mr. R. D. Cruickshank, writes, as regards the general subject, that "some varieties are on adobe, some in the swale, and some on the higher and drier land," as before stated. He adds: "The kind of soil they occupy has much to do with the maturity of the shoots in autumn, and their ability to withstand the frost. I notice that those on the high ground have always suffered least, while none of them have been very severely frosted this year." The thermometer went down to 18° one night this season, and to 20° on another. The figs have been touched regularly with frost every spring and fall since they have been planted, and on the whole have not done very well. They do not occupy a very good piece of land, and at first had a hard struggle with the gophers. For this reason it has been decided to remove from the swale those varieties that do not withstand the frost there and plant them on higher land.

The first frosts of the winter of 1892–93 came upon the figs the last days of October, very early for the district, and killed most of the leaves.

The result of the experiment can be summed up in a few words. The fig is not an entire success in this region unless the location is carefully chosen. It must be high and protected from severe frosts. When the swale on the Station tract is more fully underdrained, figs will do better there, but it is not the place one would choose for a fig orchard. A tract 200 or 300 feet higher would give better results. For family planting it would seem that the Smyrna, White Adriatic, Doreé Narbus, and several others, to which allusion has been made, are here among the more hardy sorts.

Climatic Observations.—This portion of the Coast Range is subject to greater fluctuations of temperature than has been heretofore supposed. There are many rich foothill slopes in the region that are frostless, or nearly so. Four or five miles west tomato vines grow and fruit all winter. So local, circumscribed, and peculiar are the Californian climates!

As all observers know, the mean monthly temperature can never be used as conclusive evidence of any climate. Nothing could be more misleading in reference to the climate under consideration—a climate representative of many higher valleys in the California coast ranges. The Station is situated 80 feet above the Salinas River, about 800 feet above the sea-level, and 40 miles due east of Estero Bay, with a high mountain chain—the Santa Lucia—between. There are many places in the district where the thermometric variations are even more sudden than at the Station. The following table, compiled from Mr. Cruickshank's weather reports, will show some of the peculiarities of the climate:

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Meteorological Table Southern Coast Range Station, at Paso Robles.

1891.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Barometer. (800 feet above sea).												
Mean barometer	29.45	29.26	29.32	29.33	29.26	29.23	29.21	29.20	29.26	29.31	29.39	29.52
Highest barometer	29.65	29.65	29.52	29.49	29.39	29.41	29.30	29.30	29.40	29.42	29.53	29.80
Lowest barometer	29.20	28.40	28.38	29.11	29.10	29.10	29.13	29.12	29.10	29.10	29.25	29.10
Monthly range	0.45	1.25	1.14	0.38	0.29	0.31	0.17	0.18	0.30	0.32	0.28	0.70
Thermometer.												
Mean temperature (Fahr.)	44.62	49.38	52.95	57.43	60.27	70.79	75.82	75.96	68.08	60.15	51.33	42.75
Maximum temperature (Fahr.)	68	64	76	90	89	112	112	108	104	90	78	66
Minimum temperature (Fahr.)	22	30	30	34	42	42	48	45	42	31	24	18
Monthly range	46	34	36	56	47	70	64	63	62	59	54	48
Greatest daily variation	38	28	44	47	43	52	54	53	48	50	43	38
Least daily variation	12	2	4	17	18	23	34	35	14	21	20	10
Mean daily range	26	17.50	23.19	28.73	26.38	38.86	45	45.41	36.16	35.93	34.66	22.35
Precipitation.												
Rainfall, in inches	0.55	7.29	2.35	0.77	0.07	0.00	0.00	0.00	0.00	0.00	0.00	3.05
Relative Humidity.												
Mean of month	80	77	82	74	84	62	45	44	55	58	61	62
Highest humidity	86	86	85	97	90	87	80	66	90	89	88	93
Lowest humidity	50	69	74	43	64	36	32	26	24	12	38	13
Monthly range	36	17	11	54	26	51	48	40	66	77	50	80

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Especial attention is called to the great daily variation of temperature; also, to the sudden changes in relative humidity. The greatest atmospheric dryness in October and December occurred when a north wind was blowing. The hygrometer was exposed on the north side of the house, so that the conditions were favorable to extreme indications, but in any case the record is an extraordinary one. So far as human sensations are concerned this very atmospheric dryness serves to soften materially the impressions of the temperature variations.

FIGS AT THE SIERRA FOOTHILL STATION.

At the Sierra Foothill Station, near Jackson, Amador County, the figs are planted so as to encircle a hill. Some of them are only 25 feet above the lowest point on the grounds, the bank of the mining ditch; others are nearly at the top of the hill. They occupy several classes of soil, the red (slate) and the granitic. But few are on the pure granite soil. The Foreman, Mr. George Hansen, writes that the leakage of the large reservoir on the top of the hill might have reached a few of the figs, but that the finest trees are entirely out of its reach, and none received any intentional irrigation. We have here a fine practical illustration of the suitability of fig culture to the rocky foothills of similar regions.

It is worth while to note, further, that the olives occupy the warmest part of the reservoir hill. The lowest temperature on record at the ditch is 20° F. Twenty-five feet is a small elevation, but it is likely that it makes a difference of several degrees in such a locality. When a few trees are planted on the newly cleared land beside the ditch, for purposes of comparison, the list of hardy varieties may be lessened. At present, as the Foreman writes, there is not a single variety that shows signs of having suffered from frost this season. And it was the same in the winter of 1891–92. Some trees matured late, and the wood was still green, but sound, in December. Two kinds, Du Roi and Brown Ischia, both at the top of the hill, kept their leaves later than the others, so the leaves were frozen, but that did not affect the wood. Practically none of the fifty-one varieties of the fig at the Station can be called other than hardy, as now planted, above the valley.

One point worth comparison with the other stations is that of growth. Doreé Narbus, noted as being especially hardy elsewhere, but of slow and poor growth, is "gigantic" at the Foothill Station. Other superb growers are Brown Ischia, De Constantine, Monaca Bianca, and White Adriatic. The following sorts can be called first-class growers, though not equal to the first named: White Genoa, Du Roi, Early Violet, Col di Signora Bianca, Bourjassotte Grise, White Ischia, and White and Black Marseilles.

HARDINESS OF THE FIG ELSEWHERE.

Soon after the publication of some of these facts about the comparative hardiness of different varieties of the fig (Bulletin No. 96), I received a number of letters from other observers. One very interesting statement was from Mr. George A. Raymond, a prominent fig grower whose "Rancho Palma" is at Miramonte, Kern County. He says: "I have a trial fig orchard containing last winter (1891–92) the following varieties of one-year-old trees, set out in the spring of 1891:

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California Black	Frosted to the ground.
Bulletin Smyrna	Did not frost.
White Ischia	Frosted very little.
Brown Ischia	Frosted very little.
Raisin	Frosted considerably.
Verdal Longue	Frosted a trifle at extreme tips.
Brown Smyrna	Frosted a trifle at extreme tips.
White Smyrna	Did not frost.
White Adriatic	Frosted a trifle at extreme tips.
White Genoa	Frosted a trifle at extreme tips.
Zinitzia	Did not frost.
Cerniga	Did not frost.
San Pedro	Did not frost.
Moisonne	Frosted at extreme tips.
Rose Blanche	Frosted at extreme tips.

"With the exception of the California Black and the Raisin, the frosting was really nothing, the San Pedro standing perfectly, not like yours at Tulare. Our coldest day was December 25th, thermometer, at 7 A. M., 18°. We had many when the thermometer at 7 A. M. was from 23° to 29°. This spring I have added some ten varieties."

Another very suggestive report comes from Mr. M. Gorman, of San Ardo, Monterey County. "The first three years," he says, "the figs were killed to the ground, because I irrigated them. Since then I have not irrigated my trees, and they do better. Some of my trees are four years old—White Adriatic, Mission, and White Ischia." He says that cuttings received in 1890 from Washington, of several new varieties, grew 16 inches in height the first season. The farm, near San Ardo, is about 550 feet above the sea-level, in the foothills. The variations of temperature correspond somewhat to those at the Station near Paso Robles. The greatest cold of recent years was December 25, 1891, when the thermometer fell to 18° F. Mr. Gorman's practical conclusion is that he can raise a good many figs if he does not water the trees. One of his neighbors, he says, has grown figs in the level Salinas Valley, where he thinks it is colder than at San Ardo.

Prof. W. F. Massey writes from the North Carolina College of Agriculture, at Raleigh, under date of February 19, 1892. He says: "There has been a good deal of interest in our State recently in fig culture, and a great many trees have been planted. We have been distributing several thousand plants of new sorts, and the demand upon us increases. I was rather surprised to note from your bulletin that figs seem to suffer more with you than here. We have had a cold winter—mercury one morning down to 16° above zero, in January—but none of our figs are hurt, excepting some plants a year old in a very exposed position. Even San Pedro shows no hurt. It is a curious fact that figs stand better here than in southern South Carolina and Georgia. This is due, I think, to the fact that in the warm weather of February they get excited there sooner than here, and a sharp return of cold cuts them down. So far here, our best figs are Brown Turkey, Brunswick, White Genoa, and White Marseilles. All the so-called Smyrna figs we have had, turned out to be Angelique."

Professor Massey also alludes to some olives sent to him from the University of California, and says: "They were planted in a group—some are not seriously hurt by the cold, but the Nevadillo Blanco is badly cut." "Satsuma oranges," he adds, "in a more exposed position, were only cut to the extent of losing foliage. In the warmest southeastern part of our State this orange will be perfectly hardy. It stood

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the winter a year ago, here, entirely unhurt, but our lowest temperature then was 20°."

The success that Professor Massey reports from North Carolina is very gratifying, because it shows the extent to which the culture of figs for table use is extending in the South. If the preceding notes upon California fig culture serve to show the frostiness of some localities, they also show the perfect climatic adaptation of other districts, and will warn would-be planters against loss. As a closing example of the value of such climatic observations, I will cite a case in one of the colder portions of the San Joaquin Valley. I recently visited a colony where about 180 acres had been planted to the White Adriatic fig. The soil was rich, and the trees grew well for several years, but as they were beginning to bear, the severe frosts of December, 1891, killed nine tenths of the orchard to the ground. The stumps and remaining trees are being removed, and raisin grapes are to be planted instead. If the Tulare Station had been established a few years earlier, the observations made there would have proved that the White Adriatic was too tender for the locality under consideration, and the severe loss might have been avoided. Since the publication of Station Bulletin No. 96, the attention of fig planters throughout California has been drawn to the necessity of avoiding frosty localities. There is enough land that is absolutely safe, without risking orchards for commercial purposes on frosty ground. With the planter of small home orchards the case is different; he is anxious to conquer climate as far as possible, and he is justified in experiments with hardier figs.

VARIETIES OF THE FIG.

Nomenclature, difficult in all fruits, is particularly so with the fig in California. There have been many importations under different names, and some noted varieties seem to vary much in different localities. Figs have been sent this summer of 1892 to the Station for identification, that do not resemble any of the standard varieties, and may be seedlings of the old Mission fig. Professor Massey, as previously quoted, says that what he received as Smyrna turned out to be Angelique. The Smyrna question in California has been complicated by the fact that a large fig, of fair quality in warm districts, was early planted here, perhaps before 1856, and called the "White Smyrna." Another is known as the "Brown Smyrna." Widely propagated, and a good bearer, every effort made to dry the white variety was a failure. Observations, however, made at the Stations during 1892 prove that this California Smyrna is almost identical with the Dalmatian. Growth of trees, shape of leaf, color, shape, size, and flavor of fruit are so nearly alike, that some minor variations must be attributed to the thirty-six years' naturalization of the first imported stock. The two Smyrnas imported from Asia Minor, like the Breba, drop their figs, and will probably do so, until they can be fertilized from the Capri, or wild trees. A so-called Smyrna, sent to the Central Station from a grower at the Palms, Los Angeles County, seems to bear heavily without artificial fertilizing, but it is small and of poor quality, though in shape resembling one of the Smyrnas from Asia Minor. A few years more will enable us to settle several disputed questions regarding the Smyrna figs and their culture.

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The best of the imported Smyrnas now in California appears very distinct from any European fig.

Respecting the other figs under cultivation, there is much to be said, even now, that is of value to the public. Some varieties, for instance, are much earlier than others, and are well adapted to the colder districts. Such a one is Early Violet. It is hardy, a good bearer, fruit small, brown, but of excellent quality, ripening a month earlier than most varieties. Precoce d'Espagne is also an excellent early fig for planting as a wall grower in cold regions, but it is not one of the best for ordinary culture.

The differences among varieties of figs, in point of eating quality, are as great as that among the varieties of pears, apples, or peaches. One classification is possible on color, another on shape, still another on hardiness, but the planter will be wise to consider, also, that of quality. The highest-flavored fig grown at the Stations is the Du Roi, a rather small fig with white flesh, and very smooth, thin, and fragrant skin. This fig is so delicious that if it would bear transportation fresh, which I doubt, growers would find it hard to supply the demand. For preserving, canning, or packing "soft-dried" in flat, sealed cans, as some growers have put up other varieties, it ought to rank very high, owing to its beauty and quality.

The Hirtu du Japon probably comes next, after the Du Roi, in point of quality, among the new figs. It is a dark purple fig, with yellowish white flesh, and pinkish purple calyx. There are only a few perfect seeds; other seeds show as small, dark specks in the light-colored flesh. The keeping quality of the fig is rather unusual, and it never "sours" on the tree or ground. The size is medium; the shape round and full. The tree is compact, handsome, and the greatest bearer in the whole list of varieties tested.

Brown Turkey seems to be the next best bearer at Tulare Station. For family planting this fig ought to rank among the choice. I presume that the white figs are to be preferred for commercial purposes.

There are several small black figs of high quality. Pasteliere is one that grows well and bears well. Betada and Jerusalem, two sorts not yet fruited on the coast, are very rich, and deserve planting for family use. Agen, small to medium, round, green skin, has flesh as dark as most of the blacks, and is a high-flavored variety, late-ripening, and remaining long on the tree. This fig is grown at the Stations. The older varieties all do well; among these are the Black Genoa, the favorite fig of Languedoc and Provence; the Black Ischia, called one of the best varieties for growing in pots; the greenish yellow and brown Brunswick, a rich and excellent fig.

Two figs, as grown at the Stations, appear much alike; they are the De Constantine and Rocardi. The skin is black and green striped; the flesh is coarse, though rich; the seeds are large, and the type appears to be like the old Mission fig. The green color forms a blotch at the calyx, and then runs in narrowing bands toward the stem. The trees appear to grow somewhat differently.

The Bourjassottes, white, gray, black, and green, are all coarse as compared with such figs as Du Roi.

The Doreé Narbus, hardiest of all the figs at the Stations, proves to be a small, yellow fig of rather inferior quality, though it may improve as the tree ages.

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Among the figs that should be tested at the Stations are the following: Peau Dure, a green fig, said in France to be "equal to the Smyrna for drying"; Oil de Perdrix, a very small fig, used for crystallization; also the Malta and the Castle Kennedy, both highly esteemed.

THE GENERAL VIEW.

Although the fig plantations at the respective Stations have been so newly made, some results are already evident. The Smyrnas deserve all the thought and attention they can receive. The White Adriatic does not maintain its previous reputation when brought into comparison with other kinds. Several varieties, hitherto unknown in California, promise to be valuable. The so-called Smyrna of the pioneers is not a Smyrna at all. As the orchards become older, as other sorts are added, and as artificial impregnation is tried with those sorts that drop their fruit untimely, the reports will increase in general value. The Doreé Narbus and the wild fig will also be tested as a stock for the more tender varieties.

It may be added, before leaving this subject, that there are about sixty known varieties of the round, or turbinate, figs, and about forty of the long, or pear-shaped, figs. In size, the fig varies from small varieties, hardly larger than a Green Gage plum, to varieties such as the superb Negro Larga, single specimens of which often weigh four ounces or more. The skin of the fig varies in color from nearly white, through pale yellow, green, buff, brown-reddish, and purple, to black. The flesh is white, opaline, or various shades of red; it can be described as melting, juicy, coarse, or dry; it carries fertile seeds, or mere abortive germs; its flavor varies so greatly that if the better kinds could be more generally grown, and carried fresh to market, America would soon become as much a nation of fig-eaters as were the ancient Greeks.

NATIVE SHRUBS OF CALIFORNIA.*

By Edward L. Greene.

Osmaronia cerasiformis, or oso berry, belonging to the alliance of the cherries and plums, botanically something between the two, with strong points of divergence from both, is perhaps our earliest shrub to put forth leaves and flowers. Before the end of January, if the winter be mild, he who rambles by brooklets, among the hills, may catch a breath of fresh, delightful fragrance, and so be notified that Osmaronia is already coming into bloom. Its nodding clusters of green and white, partly concealed by half-grown leaves, make little show, and the shrub is commonly of humble growth, although occasionally appearing in the dimensions of a hazel bush. It must, nevertheless, be a favorite wherever it is known, on account of the sweet odor of its flowers; not heavy and surfeiting like that of the wild plums and cherries, but most agreeable and refreshing, something to be compared to the flavor of almonds. No other flowers have such a smell; and I well remember how, in my earlier walks in California, botanizing one April day in the northern Sierra, at the

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base of Mount Shasta, where half the thickets were white and red with the bloom of dogwood and redbud, and the rocky margins of the noisy mountain streams were set full of the broad leaves and pink corymbs of the great saxifrage, all so attractive to the eye, I wondered and wondered which of the many new beauties it was that gave forth such unwonted and peculiar fragrance, until, at length, I broke off a twig of the little cherry-like bush, which was then new to me, and found that, in its modest reserve, to be the source of all the sweetness with which the air was laden.

In the foreign correspondence of "Garden and Forest" I have lately read with some interest the remarks that while in France the handsome fruits of Osmaronia are its chief attraction, in England it bears no fruit. May not this possibly be explained by reference to the dicœcious character of the shrub? Have they in England, perchance, only the staminate flowers? Much the same thing may be noted in some parts of California. About Berkeley, for example, I have never found the fruits, nor even any bushes with pistillate flowers; but on the opposite side of San Francisco Bay, in Marin and San Francisco counties, there are plenty of pistillate-flowered specimens, and the fruits are produced in abundance. There is much more dicœcism in California plants and shrubs of the Rosaceous and Pomaceous families than the authors of our books on botany have known.

Owing to inattention to this matter, our common wild blackberry, or bramble, has been published by botanists under at least three different names, as if there were three species. The oldest of these is *Rubus vitifolius*. The type so named is merely the pistillate shrub, and its flowers are commonly but one third as large as those of the staminate plants, and their petals are rounded. These, growing as they do among the staminate shrubs, the flowers of which latter are not only thrice as large, but have narrow and elongated petals, look as if they might indeed be of a distinct species. The fine figure in Hooker's "Flora Boreali-Americana," under the name of *Rubus macropetalus*, represents simply the staminate or sterile condition of what has commonly been called *Rubus ursinus*, of which the prior name, and the one to be retained, is *R. vitifolius*.

I ought here to add that in Osmaronia, also, the staminate plant produces rather larger flowers than the pistillate.

Cercocarpus betuloides, Nutt., bears some likeness to the shrubby birches, but has sparser foliage, and, consequently, little beauty to recommend it. This prevailing shrub, or small tree, of the coast mountains of the Pacific States is, however, of much botanical interest, and possibly of considerable economic value. Known to the mountaineers and miners by the name of wild mahogany, its wood is the heaviest and hardest we have; and the leafy twigs have a sweet birchy flavor, rendering them choice food for cattle in late summer and autumn, when the annual grass crop has failed.

Under the name of *C. parvifolius*, with which species it has been confounded by those botanists who have seen dried twigs only, this shrub is credited with a range in California from San Diego to Lake County, or through the southern and middle parts of the State; but it is equally common southward on the Lower Californian peninsula, and northward on the Siskiyou Mountains in Oregon. That it is a good species, better than Nuttall, the author of both of them, knew, I indicated some years

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since, in my paper on Santa Cruz Island.* The larger, proportionally broader, and nearly glabrous leaves, on which characters Nuttall seems to have relied, are indeed insufficient; they are inconstant. Small-leaved states of *C. betuloides* are often met with; but over and above a certain constant difference in the general bearing or habit, easily seen at a glance, but not easily defined, the stem and bark of the two are strikingly unlike. *C. parvifolius*, which, by the way, occupies an entirely different region of country—*i. e.*, the Rocky Mountains and adjacent interior districts, not reaching any part of California or Oregon—has a dark colored, thick, persistent, and fissured bark. *C. betuloides*, on the other hand, often much larger every way than the best developed states of *C. parvifolius*, presents, at most seasons of the year, a clean, smooth trunk, with gray bark, and this outer bark is deciduous, falling away in irregular flakes in early autumn. On this character alone *C. betuloides* will rest securely as an excellent species. By the pioneer collector, Mr. Douglas, and by the authors of the "Botany of Captain Beechey's Voyage," the small-leaved state of *C. betuloides* was mistaken for the real *C. parvifolius*, and thus began that confusion of the two species which was continued, in the books, until, in the "Flora Franciscana," I made the correction.

During my vacation journeyings of the past summer, I, for the first time, met with the curious *Fremontia californica* in its native wilderness. Particularly attractive to all botanists as being nearly related to the celebrated Hand Flower Tree of southern Mexico, eminent systematists considering it nothing more than a second species of Cheiranthodendron, I had not, from the numerous herbarium specimens I had seen, inferred its highly ornamental character. The foliage, as in most shrubs of our arid mountain districts, is sparse and small. When the Rev. Mr. Fitch, the first after General Fremont to observe the shrub, described it to Dr. Torrey as having very much the appearance of an ordinary fig tree, he must have had in view the mere outline and texture of the leaves. In these points only are the leaves like fig leaves; for they are commonly only an inch in diameter, and rusty tomentose beneath. The bark of both main stem and branches is, indeed, smooth and much like that of the fig tree, but darker, even blackish on the older trunk. But the beauty of the Fremontia is in the crowded profusion of its red and yellow hibiscus-like flowers. Each wand-like branch, at flowering time, is simply a long, solid wreath of light yellow, tinged with a rusty red; and the arrangement of the branches—the head of the tree—is as far from the conventional as the structure of the flower is unique. Growing along the steep and jagged, rocky slopes of the mountains, the dark smooth trunk will rise erect, while all the long flowering branches, not rarely 6 or 8 feet long, will hang on one side, it may be; or they may spread out in several directions, forming a flat-topped or umbrella-like body; but the bush or small tree, not rarely 12 feet in height, is always attractive if in bloom, and the flowering season is not brief. Or rather, the showy carolla-like calyces, of great firmness of texture, remain fresh a long time, and finally wither, almost without change of color, and remain attached to the growing fruit for some weeks.

Attaining its best development among the arid hills which shut in such almost rainless and overheated regions as the Mojave Desert, it is not likely the Fremontia could be made well at home in gardens, even

* Bulletin Calif. Acad. ii., 396.

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in the milder regions of the East. In its more northerly habitat, the upper Sacramento Valley, in California, it is smaller and less beautiful by far, than under the comparatively rainless skies of the southern interior. But any lover of shrubs, at once odd and beautiful, having once enjoyed the sight of this one in flower, will wish he might add it to the ornaments of home.

Garrya elliptica, Dougl. From the figure given in the "Botanical Register," more than fifty years ago, taken from a specimen which had flowered in England, one would not infer that the species deserved mention among the really very ornamental shrubs of California. Perhaps it did not find in England a congenial climate. In its native localities among the coast mountains, growing in clumps, from 6 to 10 feet high, with its dark green, leathery, wavy-margined foliage, it is never unsightly, while at flowering time it appears very uniquely beautiful. The inflorescence, while amentaceous, and therefore like that of alders and birches in kind, is of a much more showy character. The tassels, those of the male shrub, being commonly 8 or 10 inches long, very slender, and of a pale green, which harmonizes well with the dark hue of the foliage, are hung forth from two to four or five in a place, at the ends of all the branches and branchlets, and being of such length, some of them fall across lower branches and often hang in festoons, draping most gracefully and attractively the whole bush. The flowering occurs usually in early February, after the first week of mild, sunny, spring weather, and the long light chains of pale olive green, naturally of only ten days' duration at best, are sure to be gathered from the bushes, almost before the full development, by afternoon strollers in quest of earliest wild flowers.

One or two other species of garrya, found southward in the State, or in the mountains of the interior, are less ornamental, but by virtue of the strongly tonic property of their bark, they are well known to miners and mountaineers, who employ them as a remedy in ague and intermittent fevers. The bark of the cornel, or dogwood, of the Atlantic States has the same qualities; and there are botanical systematists who consider the garrya and the cornus as belonging to the same family, although they bear not the least external resemblance to each other. All the garryas have, however, the same fine-grained, very hard wood as the cornel. But, for its uniquely beautiful appearance when in flower, our *Garrya elliptica* deserves a conspicuous place in every shrubbery. Lindley described it as hardy in England; but it is doubtful whether it would endure well the dry cold of the New England winter.

Ribes tenuiflorum, Lindl. I must speak first of the bibliography of this, our Californian yellow currant; for I have long perceived that all American writers of the present generation confuse it with the Missouri currant (*R. aureum*). The two species are entirely distinct, as I have clearly seen ever since my earliest years in California. The last named does not grow either in California or anywhere west of the Rocky Mountains. The former is found along the eastern bases of the Colorado Mountains, and for some distance eastward. The confusion of the two began with Pursh, who, in 1814, had both in mind when he described his *R. aureum*. According to Lindley, Pursh's dried specimens were of the far western shrub from the Columbia River region, not then introduced into England, and his description was drawn up from living bushes of the true Missouri currant, at that time already in

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cultivation there. Nuttall had, in 1818, indicated that he considered it to be two varieties of the *R. aureum;* but Lindley, in 1829, made clear the specific differences, and gave the name *R. tenuiflorum* to the Pacific Coast species, reserving the name *R. aureum* for the one then best known, giving as his reason the fact that this had been the shrub from which Pursh had drawn up his specific character. Both species are figured in the "Botanical Register," *R. aureum*, at plate 125, but they are represented in flower only; and if these plates exhibiting mere branches in leaf and flower had left nothing untold, botanists would have been excused for treating them as one species. The essential differences between them, apart from considerations of geographical distribution, reside in certain strong characteristics of the flowers and fruits. The sole recommendation of the old and true *R. aureum*, or Missouri currant, is the delicious spicy fragrance of its flowers. *R. tenuiflorum*, all the way from middle California to the British boundary and across the country to Colorado, has flowers entirely scentless. Its berries are large, of a beautiful amber color, deepening to a paler than cherry-red in fullest maturity, and have an acidulous taste without aroma. Those of the real *R. aureum* are smaller, black, sweet, and with a decided black currant flavor. The Pacific species grows ordinarily to twice or thrice the size of the Eastern, and its fruit is valued even in the wild state in those remote, still sparsely settled and little cultivated parts of Northern California, where it abounds. It is probable that under cultivation it would rise to a place of some importance. But, as above intimated, it is entirely destitute of that one quality, the rich odor of the flowers, which has made its more easterly ally a universal favorite in spite of the worthlessness of its fruit.

Lavatera assurgentiflora, Kellogg. The number of things I shall have to say about this lavatera will be out of proportion to its merits as an ornamental shrub; for these are not great. A stout and heavy-looking bush or small tree, with a not unsightly, angular, maple-like foliage, and a profusion of rich red flowers hung on long and slender stalklets from the axils of the leaves, it is sufficiently showy to have been cultivated everywhere throughout the maritime parts of California, apparently from the early days of the Spanish settlements.

Unquestionably indigenous to Californian territory, it is never seen growing wild except around old dwellings or near gardens; and, since along with the acacias, eucalyptus, and other Australian trees and shrubs, it comes into flower soon after the winter solstice, a stranger would take it for an exotic from the southern hemisphere. Such was the impression it gave me when I first saw it, blooming beautifully in midwinter, many years ago. It is one of a considerable number of trees and shrubs which are found wild nowhere else in the world except upon two or three rocky islets, which, although politically a part of California, are barely visible above the horizon as one looks out to the seaward, on a clear day, from Santa Barbara or San Pedro.

When Doctor Kellogg named and published the species as new to science, he put upon record a tradition that the seeds of it had been brought in the first place from the island of Anacapa. It does not appear that any botanist or amateur had authenticated this supposed habitat; nor has such authentication ever yet been made. On the contrary, several intelligent men who, although not botanists, know the lavatera very well, and who have been on Anacapa repeatedly, declare

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that it does not grow there. I nevertheless suspect that if ever a zealous and careful botanist should visit Anacapa he may find it lurking among the half-cavernous niches of the basaltic columns not far above the water's edge. It should be sought in some such place, and not on the dry and exposed summit or sides of the island, where other shrubs grow.

The exact type common in cultivation all up and down western California has, within a few years, been found on one or two maritime rocks smaller than Anacapa and lying near the large island of Santa Catalina. But the principal native locality for the species is the island of San Miguel, the northernmost member of the Santa Barbara group, and an island two or three miles in extent. But the shrub of San Miguel differs in several ways, and quite notably, from that which is in cultivation, and which came from the more southerly station. It is of more robust and compact growth, making a shapely and handsome small tree; its leaves are much larger, its flowers of a deeper red, and the stellate pubescens, prevalent in the Malvaceous family, is far more abundant.

On my return from San Miguel Island in 1886, I felt some suspicions that the lavatera might be proven indigenous to the peninsula of San Francisco. Although 300 miles of sea intervene, the soil and climate of the two localities are much alike. I had seen it flourishing in abundance at the Cliff House, in wild-looking places among the bluffs overhanging the sea, and also, as I thought, in places among the sand hills rather remote from where it was likely to have been planted. I had also been informed by older members of the California Academy that it had been still more common years ago than now at various places back of San Francisco, where there were no settlements. But having revisited and carefully inspected every locality there, I became convinced that it is not indigenous on any part of the peninsula of San Francisco. The largest trees, and those appearing as if they might be twenty years old or more, are either under cultivation and where they were planted by the hand of man, or else in the vicinity of old dwellings. It is very commonly planted in rows along the western and northern sides of market gardens, where it speedily grows into an effective hedge, which, while not dense enough to be impervious to animals, serves a useful purpose in breaking the force of the cold sea winds which prevail from those points of the compass during the summer.

The leaves and twigs, abounding in mucilage, are a nutritious and wholesome food for sheep and cattle, which are very fond of them. On San Miguel, the only trees surviving in 1886 were certain large-sized ones, which bore their branches above the reach of any ruminant. The smaller ones were dead or moribund, through having been too closely browsed by the sheep.

The individual flower of this species is really very beautiful; and it is only because the branches are a little coarse and unwieldy, and the foliage apt to conceal the richest profusion of the flowers, that the shrub, as a whole, is not highly attractive. The petals, an inch long or more, arranged as in the hollyhock or mallow, are of a peculiar deep pink color, veined with almost a carmine. On first unfolding they spread apart only so far as to form a bell-shaped corolla, afterward becoming abruptly deflexed from a little above the base, so that the body of the corolla is inside out; and since the flowers are pendulous, each on a long, slender stalklet, this inversion of the corolla gives the

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fullest exposure of the stamens and pistils to the favoring agency of the winds. The seeds, which are under all circumstances matured in abundance, germinate freely where they fall; and so the species spreads wherever planted, if not too far from the sea. In the interior of the State I have never seen it.

Although none of the other three North American species of this genus are properly Californian, inasmuch as they inhabit each an island of its own off the coast of the Mexican territory of Lower California, still they must be mentioned in connection with *L. assurgentiflora*, and I name first of the three *L. venosa*, confined to the little island of San Benito, the position of which is about 500 miles south of the islets occupied by the best known species. And while an intermediate islet has yielded a third, and a very different species, the two which belong to those widely separated extremes of our lavatera archipelago, although so distinct that no botanist having seen them both will be likely to think of them as very closely related, they are far more like each other than either one is like either of the two whose geographical range is intermediate. This is another strange fact to be noted in connection with this capricious sorosis of sea-rock shrubs.

L. venosa has about the same foliage as that of *L. assurgentiflora*, though of a deeper green, with even less pubescence. Its flowers are also hung each upon a long and slender peduncle, but they are rather more than twice as large, commonly measuring three inches from tip to tip of the widely spreading petals. The color of the petals is mainly white below the middle, of a rich violet above, about five heavy veins of the violet streaking the otherwise white portion of the organ down to its base. The leaves being rather smaller than those of *L. assurgentiflora*, and the flowers twice as large, it is far more showy, and the individual flowers are greatly admired by the few who have seen them. Two years ago some small seedlings were brought to me from San Benito by a friendly naval officer whom I had asked to do me the favor, and the one surviving individual of the lot, now blooming luxuriantly at Berkeley, is doubtless the only one alive upon this or any other continent. Its mode of growth is altogether peculiar. There is always an erect main stem, from which the branches take a descending instead of an ascending or even horizontal direction, so that the trunk is ultimately concealed by the leafy and flowery branches, whose tips reach the ground and then turn up or spead or straggle about. My bush having been continuously in flower since the beginning of February, promises now a crop of seeds. It seemed to endure the slight frosts of our "Bay region" about as well as does its familiar ally, whose native station is far more northerly than its own.

L. insularis, of the Coronado Island, 7 miles off the coast of northern Lower California, and *L. occidentalis*, of Guadalupe Island, are more robust shrubs than either of the aforenamed, and their stout branches, short and firmly ascending, combine to form a low, umbrella-like head; their large greenish and violet-streaked corollas are strictly bell-shaped, inserted on short peduncles, and are mostly concealed by the foliage. The essential distinction between these two, as species, lies in the foliage, and is one which an amateur might overlook, although the eye of a practical botanist would quickly both catch the marked difference and recognize its specific importance. In *L. insularis* the five or seven lobes of the leaf radiate all around the end of the leaf-stalk, giving quite a

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star-shaped outline to the whole. In *L. occidentalis* the lobes all incline forward in such wise that the leaf is rendered digitate, or hand-shaped. These two species, each restricted to its own island, and the two islands more than 200 miles apart, form a group by themselves, both having gray-green foliage, short-stalked violet and green flowers, with corollas broad and open even to the base, but not recurved or reflexed; both also have that compact habit which, making display of the handsome pointed foliage, compensates for the concealment of the flowers.

It is a curious fact that while *L. venosa*, the home of which is nearest the tropic, endures well the winter of the latitude of San Francisco, *L. insularis*, whose locality is only 30 miles below San Diego, is more tender. Of two specimens of the latter which I brought to flowering here from seeds gathered while on Coronado in 1885, one was killed by frost two years ago, and the other succumbed a year later.

But the main charm of these shrubs is that which they possess in the eye of the student of plant geography. The genus Lavatera belongs to the Mediterranean region of the Old World, where there are perhaps twenty species. There is one in Australia. On the continent of America not one occurs. On a few Pacific Coast islands and islets lying at distances of from 7 to 25 miles from the mainland, we have three, with a fourth on another which lies at a greater distance.

That all these species, even when transferred to the latitude of San Francisco, begin their new growth and exhibit their flower buds about Christmas, comes of the fact that the climate they are all used to is in effect a tropical one. On their respective insular shores they all grow at a little distance from the water-line, where the temperature is as mild and equable as possible and where there is never the slightest frost; and there is no island on all the coast whose vegetation does not seem to be about three weeks earlier than that on the adjacent mainland.

The three southerly species here spoken of, as yet almost unknown except to two or three Californian botanists, will be slow in getting into cultivation. The open air climate of San Francisco, even, is rather too severe for them; but on account of their great botanical interest as well as for their singular beauty, they are sure to receive further attention.

Against the five or six native species of plum with which the Atlantic States are credited, the Pacific Coast has only one, though this appears in different localities under two very well-marked varieties. The type is *Prunus subcordata*, Benth. The variety *Kelloggii*, Lemmon, is not well known, and may possibly, at some future day, be admitted in the rank of a species. But the species in the typical form is common in many parts of California, though along the seaboard it is so rare as to have escaped the notice of all the early explorers, Menzies, Chamisso, Douglas, and even Nuttall. Not until the year 1847, when Hartweg botanized up the Sacramento to the foothills of the Sierra, was our wild plum brought to the knowledge of botanists.

It is a common observation that, in many genera of plants common to the Old World and the New, it is the Pacific Coast species, rather than those of Atlantic America, which make the nearest approach to Old World types; and this holds good in respect to the Californian plum. It was more intimately related to *Prunus domestica* and other European or Asian plums than are any of the Atlantic Coast species. Indeed, the Atlantic group, by their divergence from the plum-tree genus in one or two particulars, were what led certain eminent botanists to

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regard plums and cherries as congeneric. In the Old World the plums, as a genus, have this fine mark, that their leaves are rolled up from edge to edge in the bud, while the cherries all have theirs folded together lengthwise. But all the plum trees indigenous to Atlantic North America have been found to agree with the cherry trees, in that their foliage is conduplicate in the bud. Our *Prunus subcordata* is not at agreement with its American cousins in this regard, but has that rounded foliage, convolute in the bud, which betrays its closer affinity with the species of another continent. In the color, texture, and flavor of its fruit, it is, however, quite like the other American wild plums, and the quality is variable, according to the locality. And, although exotic plums are cultivated with all success in almost every part of California, the improvement of our native species has not been neglected. In some instances, cultivated seedlings from this parentage are said to have already yielded fruit very superior in size and quality to the best products of the wild tree.

As above intimated, the shrub is not common except in the lower altitudes of the Sierra Nevada. There, and especially toward the northern parts of the State, it is plentiful along the streams, where, attaining the shape and dimensions of a small tree, it forms considerable thickets, and, in places remote from the older and fruit-growing settlements, the wild plums are valued, and are, in fact, not far inferior to some of the domestic sorts. In the Coast Range I know of no locality where the species is at all common. One small clump of it, in a cañon a few miles east of Oakland, and another on the grounds of the University at Berkeley—in a secluded nook, where it is no doubt spontaneous—are all I have been able to record as Bay-district stations for it. These bushes flower in March, and the blossoms, of rather large size for those of a wild plum, in fading assume a rosy tint, such as I have not otherwise noticed in plum blossoms.

Neither the Atlantic slope of North America, nor the Pacific slope proper, has any native species of peach and almond genus, Amygdalus; but the Mexican region, including its northern extension, the interior basin of the United States territory, has, perhaps, three or four. At least one of these, *Amygdalus Andersonii*, Greene, comes within the borders of California, east of the Sierra Nevada, and is no rarity among the rocky hills and mountains which inclose the great Colorado Desert of the southern counties. The shrub was first made known to botanists under the generic name of Prunus, and hence it has been called the Desert plum. But whoever sees it in flower will recognize it at a glance as congeneric with the peach and almond, rather than with the plums. When out of bloom it is about as inconspicuous as other desert shrubs, for the foliage is both small and sparse. Its associates are the smaller agaves, yuccas, and the bristling opuntias and other cacti which prevail in those verdureless and almost rainless districts; and then, rooted firmly in the scant soil of crevices and fissures of sunburnt rocks, in February it clothes itself with a fine display of rose-red blossoms, and so becomes an ornament to a hard landscape otherwise enlivened at this season only by the red and yellow of certain cactus blossoms. The shrub is low and bushy, perhaps seldom attaining a man's height; and to its flowers there succeed, in their season, the small, velvety drupes, scarcely more than a half inch long, which, when ripe, divest themselves of their thin, fleshy, external coat, after the manner of the com-

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mon almond, and expose a small, nearly smooth putamen, or nut. I have not heard of any attempts to cultivate this native almond, either in the fertile and fruitful regions of California proper or elsewhere. It is even something of a rarity in the herbariums of the botanists, though this is owing simply to the fact that the desolate and uninviting regions which it inhabits are so seldom visited and so little cultivated by even the most zealous of botanical collectors.

THE UNIVERSITY BOTANIC GARDEN.

By Edward L. Greene.

As the teaching of agriculture calls for experimental farm land, and instruction in horticulture presupposes experimental orchards and gardens of economic plants, so does thorough work in botany demand the botanic garden; and a long-established and well-stocked botanic garden is a part of the pride of almost every university in Europe at the present time.

At Berkeley, while orchards, and gardens of economic plants, on a small scale, have been coeval with the foundation of the University, the garden distinctively botanical is a new undertaking. In the autumn of 1891, the Board of Regents, in response to the request of the head of the Department of Botany, placed a few acres of excellent ground at the disposal of the department for purposes expressly botanical. Our first object to be gained through this enterprise is living material for the illustration of the lecture courses in systematic, medical, and economic botany. Another and an equally important service which such a garden should render, would be that of enabling advanced students and professional botanists to perfect their knowledge of the affinities of plants, and carry on various researches upon the life history of vegetal organisms. It is therefore most desirable that, if possible, all the natural families of plants should be represented, and each by as many genera and species as possible; so that anything like a full-stocked botanical garden must be a thing of slow growth. It cannot be made in a year, or in a decade, even when every facility is given and the funds are unlimited.

In default of water for irrigating such shrubs and trees and perennials as would not otherwise survive our long summer drought, and without conservatories for the preservation of the thousands of species whose homes are in the tropics, we are making our first beginnings by getting together as rapidly as we are able, the native growths of the State of California, and of the regions adjacent. These alone number thousands of species, and a great proportion of them will thrive in our midst without either tropic temperature or artificially applied moisture; though for the numerous aquatic species and bog plants, as well as many hundreds of things which inhabit exclusively our higher mountains, bog gardens and cool rockeries are indispensable, both of which will call for a small perennial supply of water, whenever the necessary preparations shall have been made. For the present we content ourselves with accumulating, by the aid of various collectors, such species as will thrive in the soil and climate of the precincts of the University without these artificial conditions.

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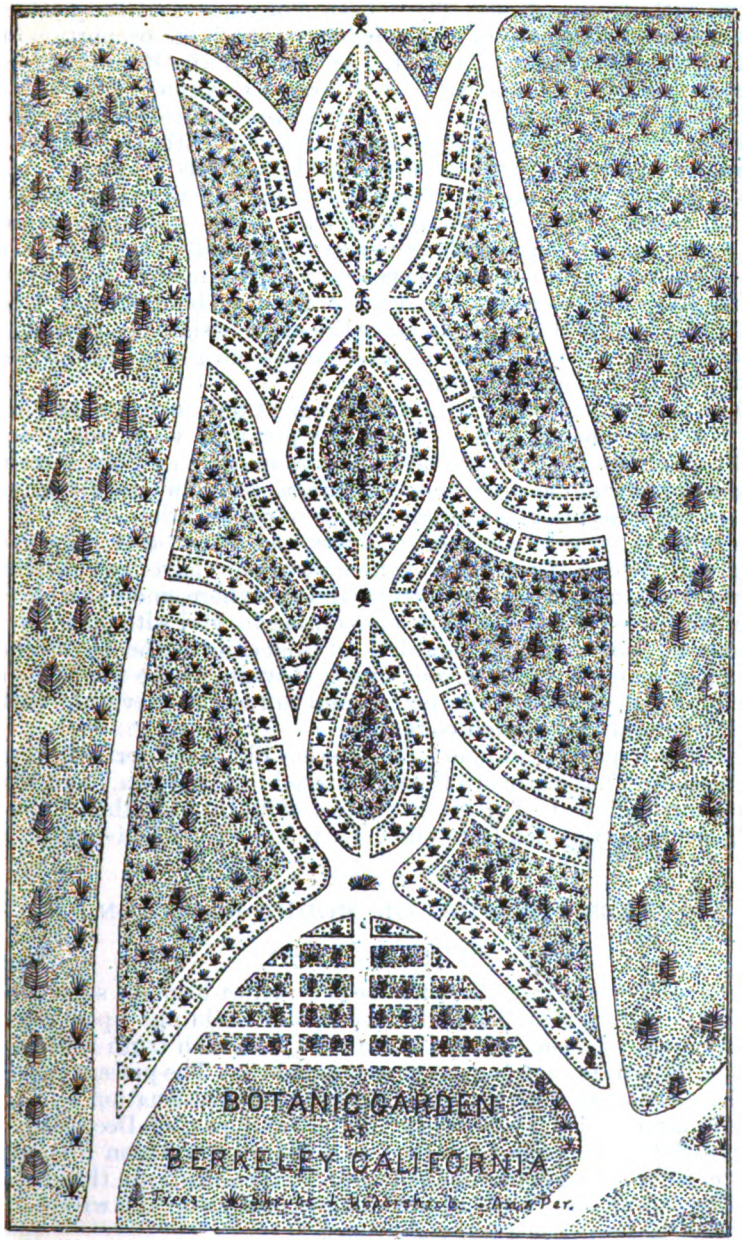

On the small plot assigned us a year ago, the garden plan of which, laid out by Mr. Ivar Tidestrom, a special student in the department, we have already established as many as six hundred kinds of native plants and shrubs, besides some two hundred from the Atlantic slope, ordered by way of experiment, with a view to determine in how far the native vegetation of that side of the continent could be depended on to grow

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with us without irrigation. The measure of success already attending this experiment is gratifying. Probably a very large proportion of the plants of the Northeastern and Middle States of the Union will easily make themselves at home with us without irrigation. And the same is true of those of Japan, in so far as we have been able to test them.

During the past season, by the help of several enthusiastic seed collectors among the students—men who had the needs of our new garden in view during their summer-vacation rambles in the mountains—the stock of seeds of native plants and shrubs has grown to represent double the number of species which we had last year; and, as more funds had been allotted for purposes of collecting for the garden, it became necessary to enlarge the garden tract. The Board of Regents have now added to it more than twice the space assigned a year ago, and this we hope to fill with growths principally indigenous to the Pacific Coast, within the next two years.

While the garden is not primarily designed to be ornamental in any way, but only useful, from a botanical point of view, yet even our small beginnings have elicited admiring comment from many visitors; and the garden is sure to become, within a very few years, one of the most generally appreciated ornaments of our institution.

The surplus seeds of our native clovers, and many other plants which the garden yielded at the close of the first season, have been distributed to various botanic gardens in Europe and elsewhere, and valuable packets in exchange for them are already coming in, and with them, written expressions from eminent botanists, of welcome to the beginnings of such a garden on this coast, from which they may hope to obtain more and more of such Californian plants and shrubs as have not hitherto been introduced into foreign countries.

On our own part, a number of new scientific facts, derived from our garden studies, have already been published in "Pittonia," and a series of such articles will shortly be inaugurated in "Erythea," the new journal of botany issued from our department of the University.

TREE PLANTING ON MOUNT HAMILTON.

By Charles H. Shinn.

For several years past there has been an effort to plant some trees on Mount Hamilton, near the Lick Observatory buildings upon the crest, and upon the adjacent slopes. It may be said with truth that nothing of much importance has yet been accomplished. The present report can only be considered a preliminary statement of the situation as I understand it after a visit to the place in the early part of December, 1892. The possibilities of tree planting upon Mount Hamilton are very attractive, and I strongly recommend greater expenditures in this direction, notwithstanding previous failures due to planting at the wrong season and under improper cultural conditions.

PREVIOUS PLANTINGS.

In 1889 about fifty trees were sent from the University gardens to Mount Hamilton. Again in 1890, but too late in the season, a large number of trees were planted, few of which remain. Cork-bark elms and California soft maples are the most promising deciduous trees. *Sequoia*

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gigantea (the Big Tree of the Sierra), *Libocedrus decurrens*, *Thuya gigantea*, *Pinus Austriaca*, and a few other conifers, such as the Monterey cypress and the Monterey pine, have done fairly well. The most promising tree of all is the sequoia. The redwoods died; they are entirely unsuited to the locality. The total coniferous tree planting of 1890 consisted of three hundred and sixty trees of six species, all natives of the Pacific Coast. About fifty fairly healthy trees, and perhaps as many more that may live, now remain from the plantings of 1889 and 1890.

In every case it was necessary to blast out a hole in the rock and fill it with earth hauled from the gulches. The winds are very strong on the summit, and the summers are dry and hot. The water supply is sufficient to give trees a start, but of course they must be species that are well adapted to the extremes of heat and cold, moisture and drought, for irrigation can only be upon a small scale and for a short time.

MOUNT HAMILTON CLIMATE.

The nature of the horticultural problems presented by the more rocky and arid portions of the mountain can be understood better from the following notes taken from the publications of the Lick Observatory. Since 1880 the least annual rainfall has been about 13 inches; the greatest has been more than 58 inches (from July, 1883, to July, 1884, inclusive). The mountain generally receives 33 inches or upwards. There is evidently rain enough for a great variety of plant life. The "dry months" are said to be May, June, July, August, and September, but in 1883 more than 7 inches fell in May, in 1889 more than 3 inches, and during eleven years only one May was entirely rainless.

The maximum and minimum temperatures are also necessary factors of the problem. The following table will illustrate the range of the thermometer:

Month.	Highest Temperature.	Lowest Temperature.	Mean Maximum of Month.	Mean Minimum of Month.
1881—January	56°	28°	49°	36°
February	69	24	52	36
March	80	18	55	37
April	82	32	68	45
May	90	34	71	48
June	89	35	77	51
July	89	41	81	58
August	87	39	79	56
September	89	37	73	51
October	68	25	53	36
November	65	26	46	31
December	63	27	50	36
1882—January	58	18	43	29
February	53	16	46	28
March	71	21	50	33
April	75	22	57	32
May	84	40	73	53
June	83	40	72	51
July	92	53	83	62
August	94	50	84	62
September	93	34	77	58
October	76	30	60	42
November	70	26	54	35
December	71	20	61	33
1883—January	64	14	47	35
February	66	13	47	31
March	70	27	60	43
April	67	21	57	33

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It is hardly necessary to carry this table out at greater length. The only lower temperature reported was in February, 1884, when the thermometer fell to 12°. The olive will not endure greater cold than 14°, and should not be planted when the temperature is even below 16°. It is therefore useless to try olives on the top of the mountain. But places can probably be found within a mile of the Observatory, where the temperature has never gone below 16° or 18°; in such places olives would thrive. The aggregate degrees of heat of the summer months is sufficient to ripen the olive upon all the warmer slopes. The sudden and great changes, as illustrated by the table, render the choice of trees that will grow upon the peak an extremely hard task.

THE SYSTEM OF PLANTING RECOMMENDED.

All planting of conifers attempted upon the peak itself should not be later than February or March. Only the true mountain species, such as *Sequoia gigantea*, *Pinus Lambertiana*, *P. ponderosa*, *P. Jeffreyi*, and *P. strobus*, should be used here. The specimens chosen should be of medium size, in separate boxes, grown outdoors, not under shelter. They should be taken to the peak upright, in a wagon, planted without disturbing the roots in the least, mulched, and braced against the wind by pieces of rock and stakes. The holes should be blasted and picked out deeper and wider, and refilled with leaf-mold from pockets in the ravines. A mulch of manure and straw from the stable is desirable. During the summer each tree should have several bucketfuls of water once a month; the second year it will have become rooted in the shattered rocks. Fifty trees chosen and planted in this manner will give more satisfaction than a thousand of the ordinary balled conifers of the trade, satisfactory enough in the fertile valleys, but not able to endure the searching tests of Mount Hamilton.

Besides such replantings upon the platforms of rock around the Observatory, the Director's residence, and the narrow "saddle-back," where the astronomers' cottages hang upon the edge of a dizzy cañon, there can be some forestry work done by sowing seeds in the chaparral to make future coppices, and by planting acorns of hardy oaks, and other hardy, large-seeded trees, in groups, "with a crowbar," covering, of course, with surface soil. These ought to be planted in the autumn before the rains, but early winter will do reasonably well. Some American black walnuts, also some California native walnuts, have been sent up to be planted in this way. The native Torreya, or nutmeg tree, is worth trying, and all of the semi-alpine oaks.

ADJACENT PLANTATIONS.

The heads of the ravines and the small plateaus nearest the peaks fortunately offer much easier problems to the planter. There is more soil there, the force of the winds is somewhat broken, and the rays of the summer sun are less perpendicular to the plane of the slope. There are large oaks, in fact quite a forest of them, and one hillside has been plowed and cultivated. One plateau of 5 acres would make an excellent apple orchard; another, higher up, is suited to a collection of mountain species of conifers. The surface should be broken, and the grass and weeds kept down by cultivation, as, otherwise, small trees

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would lack moisture. Several small plantations could be established within easy walking distance of the Observatory, and will give better results than the efforts to grow trees upon the rock platform of the summit of the mountain. The need of shade and shelter around the buildings upon the peak is most pressing, and the effort to establish a few more trees of the hardier species there must not be neglected for easier places.

MANAGEMENT OF THE WHOLE TRACT.

Hitherto all the planting attempted has been at or near the top of the mountain. The real possibilities of the large, and for many uses very valuable, tract of wild land owned by the University have been neglected. The tract consists of 2,600 acres, covering a range of 1,500 feet in altitude, from about 2,700 feet above the sea, to the crest of Mount Hamilton, 4,200 feet high. By a comparatively slight additional expenditure, the reservation could be increased to 3,000 or 3,500 acres, and this would greatly add to its future value as an Experiment Station for hardier fruits and forest trees. In parts of Italy the olive thrives at an elevation of 3,200 feet, and in Algeria at 4,800 feet, while bearing orchards are not uncommon at 3,000 feet above the sea. The olive requires thorough cultivation, but needs no irrigation in the Mount Hamilton district, where the rainfall is sufficient. It endures summer heats of from 100° to 120°, but as before stated, the winter temperature must not be less than 14°.

From both the botanical and the horticultural standpoint, this Mount Hamilton tract of land is one of the most interesting areas to be found in the entire Coast Range. It ought to be utilized, and portions of it would in time yield a very considerable income, probably enough to pay the expenses of planting the other parts.

There are many warm "flats" containing rich soil and flowing springs. Here orchards of olives and the deciduous fruits will thrive. Peaches, apricots, and prunes are growing well in similar localities. About 3,200 feet would probably mark the natural limits of such orchards, but the hardier apples and pears could be planted higher up the mountain. If 500 or 600 acres prove well adapted to these cultures, it would be all one could expect. Possibly, in the course of time, olives could be established over a still larger area of the rocky slopes.

For pure forestry treatment, after the best European methods, with modifications to adapt them to California conditions, there are a thousand or more acres that can be covered in the course of time with as fine a coniferous forest as that which clothes the base of Shasta.

Ultimately, with sufficient funds to carry on the work properly, every part of the tract, except a few precipices too steep for trees to obtain a foothold, can be covered with vegetation This, the Director assures me, would not only not injure the astronomical value of the Lick Observatory, but would undoubtedly steady the atmosphere and improve the general conditions.

The creation of profitable orchards upon the richer portions of the 2,600 acres belonging to the Mount Hamilton reservation, and of equally valuable forests of sugar pine, yellow pine, and Sierra sequoias, will undoubtedly be the task of a lifetime, and it will be hard to find men who combine the requisite knowledge and energy for its accomplishment. But I know of no better place for a forestry station of the first rank, to

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deal directly with the practical problem which the State and National Government are just beginning to recognize—the utilization of our rough lands, the reforesting of denuded mountains.

DISTRIBUTION OF SEEDS AND PLANTS, AND DONATIONS RECEIVED.

By E. J. WICKSON.

(*Experiment Station Bulletin No. 95.*)

The report of this Station for 1890, which is now in press, contains interesting tabulated statements concerning our distributions of seeds, plants, etc., during the years 1886–1891, inclusive. The following is a condensation of gross amounts of material distributed:

	Numbers of Plants and Cuttings.	Ounces of Seed.
1886–7	5,375	3,112
1887–8	5,815	6,474
1888–9	11,140	8,125
1889–90	3,959	5,669
1890–1	11,189	6,614
Totals for five years	37,478	29,993

The distribution of plants and cuttings included twenty-six species and of seeds thirty-seven species, including a much larger number of varieties. The total number of individual applications received during the five years was 3,023, and material was mailed to 1,362 Post Offices and sent to 688 express offices. Each year almost every county in the State was included in the distribution. Another table in the report presents the financial showing for the five years, and credits applicants with sending remittances ranging per year from $291 70 to $561 64 as extremes. These amounts have not in any year quite equaled the cost of distribution, the small balance being supplied from the Station funds. This fact is not objectionable, for the work is very satisfactory in its results. Experience proves, however, that requiring a small contribution insures the applicant's interest, and relieves us from the profitless work of supplying the throng of people who always carelessly send for what costs them nothing, and who, as a rule, give no attention to the trial of the material sent them, and therefore do not report results. Our distribution contemplates the acceptance of an obligation by the applicant to faithfully experiment with the material supplied, and to report success or failure. That this obligation is conscientiously discharged by a large proportion of our correspondents is shown by the full data credited to such sources in our report for 1890. This distribution from the Station is for the purpose of securing wide trial of growths new to the State, and does not include common trees, plants, and seeds, which can be had from dealers. For this reason we do not invite applications for general supplies of garden seeds. We cannot furnish them.

Terms.—To meet the expenses of packing and postage, applicants are requested to send the amount specified in connection with each descrip-

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tion below. If they desire seeds sent by express, applicants need not send the amounts specified for postage, *but all orders for* SEEDS *by express* must be accompanied by a remittance of 25 cents to pay for packing. Applications may be made for one or more kinds of seeds, *but an applicant should not order more than one package of a kind.* In case any kind of seed becomes exhausted, the money sent will be returned, unless a second choice is mentioned by the sender. Postal notes are requested instead of stamps whenever practicable. Any surplus left after filling orders will, as far as possible, be returned to the senders, deducting letter postage.

ESCULENT ROOTS AND TUBERS.

The manifest disposition among our correspondents to try locally several plants which are prominent sources of food for men and animals in other sub-tropical climates, induces us to offer the following, without, however, in all cases guaranteeing their fitness for California conditions:

Cassava (*Manihot aipi*).—This plant (sweet cassava) has recently been especially inquired about by Californians who have heard or read of its commendation by those who use it for human food or for cattle in the Gulf States. Through the courtesy of Dr. W. C. Stubbs, of the Louisiana Sugar Experiment Station, we have secured a supply of the stems, by which the plant is readily propagated. Cassava is chiefly grown in the West Indies and tropical America, and in Florida and Louisiana. As California conditions are quite in contrast with those prevailing in these moist regions, it is not wise to forecast wide success for the plant in this State. It is quite possible, however, that it may prove satisfactory in some situations. It is commended in Florida as a kitchen vegetable used as potatoes are, also the grated root is used for bread, puddings, etc. For cow-feed both the leaves and roots are used, the latter being described as far better than sweet potatoes as a milch feed. The fleshy roots grow to a length of 3 or 4 feet, and are readily pulled out of the loose soil, which is best suited to its growth. The roots must be pulled only as desired for feeding, and the supply is continuous the year round. It is estimated that from 10 to 50 tons can be grown to the acre. The plant is most readily propagated by stem cuttings, which are made about 6 inches long; the cuttings placed 4 feet apart each way and wholly buried in the soil to a depth of 3 or 4 inches. In the South, it is usual to give but little cultivation, except hoeing to keep down weeds until the plants get a good start. In this State, summer cultivation may be necessary to retain moisture. In locations free from frost, and where the soil is well drained and warm enough to admit of planting of tender vegetables during the winter, the cassava cuttings may be planted as described above as soon as received. Where there is danger of frost or likelihood of cold, water-soaked ground for some time, the cuttings should be stored in *damp* sand and planted out when the soil is in good condition in the spring. We will send a package of cuttings by mail for 10 cents.

Taro (*Colocasia esculenta*).—This plant, which will be recognized by most readers as a leading food supply of the natives of the Hawaiian and other Pacific islands, is grown here and there throughout California as an ornamental plant. Recent experience reported from San Diego County creates a presumption that in some localities in California, taro may become of economic importance. The tuber or corm is highly pala-

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table and nutritious either boiled, baked, or made into bread. The leaves are also said to be palatable cooked as spinach. Thorough cooking is necessary with both leaves and roots to rid them of acidity and poisonous principles. Taro may be grown in ordinary garden soil and with garden culture, or it may be planted along the sides of streams, or in marshy places. It will endure complete submergence of the roots, and is sometimes grown on beds artificially flooded. Quicker and larger growth of the corm may be expected in the moister situations. Heavy frost cuts the leaves to the ground, but does not kill the plant. A plot in our Experimental Garden has survived a temperature of 25° F., and the plants have grown undisturbed for several years, filling the ground with tubers, which are rather small because of the crowding and scant moisture in a heavy soil. Planted singly, and grown under more favorable conditions as to soil and moisture, great increase in size may be expected. The tubers should be set in rows about a foot apart. We will send a small package by mail for 10 cents.

Jerusalem Artichokes (*Helianthus tuberosus*).—This old plant has recently received such high commendation from a few California growers that we offer tubers from our garden to others who may desire to experiment with it. We have grown Jerusalem artichokes for a number of years, and have produced the tubers at the rate of from 1,000 to 2,000 bushels to the acre, according to the season. An interesting account of the growth and uses of the plant was given in our report for 1884, copies of which can still be furnished to applicants. The following record of experience by Mr. F. P. Beverly, of San Mateo County, will indicate the adaptations and the uses of the tubers as stock feed:

"I planted the tubers on the driest part of the place, in a corner in my grain field, in furrows about 4 inches deep, and obtained a crop of about 4,000 pounds per acre. I, however, paid very little attention to them until last year, when I again planted about a pailful of tubers. This spring I secured enough to plant about two acres. I have been feeding them to my pigs, and also to my cows, and I had to separate the cows from the larger pigs, as I had to watch them to keep them from fighting each other. The cows seem to relish them, and my pigs never did so well. The beauty of the artichoke is, it can be left in the ground until the following spring and will keep well. The pigs will dig for themselves, and will do well with hardly any other feed."

When hogs are put upon the field they will leave enough to produce a crop the following season. The ground can be cleared if desired by plowing out early in the growing season, when the young plants are about a foot high, as then the old tubers have rotted and new ones have not formed. Planting and cultivation should be the same as with potatoes, except that a single tuber is enough to a hill. We have two varieties—White French and Red Brazilian. The former is highly esteemed by some as a table vegetable, either boiled or used in soups or salads. The red variety is perhaps superior for stock purposes. We can furnish both sorts if desired at 10 cents per package of each by mail.

FORAGE PLANTS.

Our report for 1890, which will soon be ready for distribution, will contain much information concerning forage plants which we have previously distributed. The success therein attributed to some plants leads

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us to offer the seed for still wider distribution this year in connection with other seed now offered for the first time.

A Waste Land Forage Plant—Elliott's Sida (*Sida Elliottii*).—The demand for plants which will catch and hold on upon the wild pastures of the State is constant. We have already introduced several which have won approval in some localities, but have failed in others. This year we offer seed of another, which may prove useful to some of our stock growers. Our attention was called to this plant in 1889 by Hon. G. D. Tillman, M. C. from South Carolina, who has given much attention to the introduction and growth of forage plants suited to his own State. His communication, August 31, 1889, was as follows:

"I inclose some seed of a new plant, which made its appearance in my yard about three years ago. It is a number one pasture or green manure shrub or little bush, which grows spontaneously to a height of 1½ to 2 feet. Cattle and hogs are very fond of it; horses and mules as yet do not seem to like it. The plant has a long tap root. I believe it will prove a godsend for your stock ranges in California, taking possession of all your waste places and wild lands. It seems to prefer hard clay or rocky land. It is also a wonderful honey plant for bees. Just scatter the seed on the hills, and in a few years it will cover the whole surface. In the meantime pasturing does not hurt it, but the plant is worthless for either hay or soiling."

The seed received from Mr. Tillman was sown in our garden and germinated readily. Our botanist identifies the plant as *Sida Elliottii*. It is a member of the Malvaceæ, or mallow family, which are all innocuous, mucilaginous, and nutritive plants. Lavatera, which is our native California genus, is of good repute as a forage plant, and it is likely that this Sida will prove desirable in this State, as Mr. Tillman finds it in South Carolina. It grows finely in the heavy clay of our garden, and the plat which received no irrigation whatever looks more thrifty than another plat, which was moderately watered through the summer. It sends down a long tap root, and while young is quite leafy and succulent. It seeds freely and promises to extend itself, as Mr. Tillman describes. We do not apprehend that it would be difficult to kill out by cultivation, but we do not advise sowing the seed except on places designed for permanent pastures, and not on meadows designed for mowing. Scatter the seed, as Mr. Tillman advises, on hilly pastures, scratching it in here and there with a rake. Mark the places so that it can be looked for afterward. Seed will be sent by mail in small packages for 3 cents.

Texas Blue Grass (*Poa arachnifera*).—This grass can now be commended as especially valuable in many parts of the State. We furnish root-sets in 8-ounce packages for 8 cents each, by mail. By planting a small plot, the grower will soon have roots to plant a large area if the grass commends itself.

Other Forage Plants.—There is still demand for the forage plants which we have formerly distributed. Some of them have proved very successful and valuable, as is shown by our report for 1890. It is desirable to have as wide trial as possible of all of them: Japanese wheat grass (*Agropyrum japonicum*); tall oat grass (*Arrhenatherum avenaceum*); Schrader's brome grass (*Bromus unioloides*); Hungarian brome grass (*Bromus inermis*); hairy-flowered paspalum (*Paspalum dilatatum*); Millet grass (*Milium multiflorum*); snail clover (*Medicago turbinata*); espar-

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cet or sainfoin (*Onobrychis sativa*); Jersey kale—a tall-growing collard, producing a vast weight of feed on moist land. Kale should be grown and set out like cabbages. Each of the above will be sent by mail in 4-ounce packages at 5 cents for each kind ordered.

ANTI-GOPHER PLANT—EUPHORBIA LATHYRIS.

There is a periodical announcement that some one has secured immunity from gophers by the growth of a plant which is claimed to be potent in killing or banishing them. Each such announcement brings us a flood of correspondence as to the alleged efficacy of such a plant. We conceive that the best way to inform the public on this subject, and to determine whether the plant has value as a "gopher-fuge," is to offer the seed to all who feel inclined to experiment with it.

Perhaps the first declaration of the existence and use of such a plant as a repellant of gophers, was made by the late General Vallejo at a meeting of the State Horticultural Society, in April, 1885. He said that he had, some time previously, received from Mexico the seed of a plant called "Cruz de Malta," and had sown it widely over his place in Sonoma Valley, with the banishment of gophers as a result. At our request General Vallejo sent some seed to the University, and it was seen that the plant was the "Giant Spurge" or "False Caper" (*Euphorbia lathyris*), known both in this country and Europe as an ornamental plant, its seed-vessels being used in northern Europe for pickling instead of the true capers, the flower buds of *Capparis spinosa*, which is not hardy enough to succeed in the higher European latitudes. The spurge has a milky juice, and is somewhat poisonous—serious sickness of children having been induced by eating the attractive berry-like seed capsules.

The name "Cross of Malta," which is sometimes given the plant, is derived from the rectangular arrangement of the leaves in the young plant. As it matures, laterals shoot forth from the axils of these leaves, which have a different foliation, and upon these laterals the bloom and fruit appear.

The point to be determined by the present distribution of the seeds of *Euphorbia lathyris* is whether it has any influence in ridding its vicinity of gophers, either by poisoning them, as believed by General Vallejo, or by driving them away, as others have conceived. Our own belief is that it has no effect in either direction. We have grown it in our Economic Garden for a decade or more, and still the gardener has not been able to relax any of his watchfulness for gophers. In fact, they have been found at work quite near to the plants. Still, as has been stated above, almost every year the local papers announce some one's success with a "wonderful anti-gopher plant," and in every case we have followed up, it is the same "Giant Spurge," which is credited with the beneficent work. Our soil, however, is a stiff adobe, and cases of success with the plant have been mostly reported from regions with sandy soils. The seed should be treated as ordinary flower seed, sown in the open ground. We will send a small packet to each applicant by mail for 2 cents.

SUGAR CANE.

The success attained in the growth of sorghum varieties for syrup manufacture, and the present prominence attaching to the beet-sugar industry in this State, have caused renewed inquiry concerning the possi-

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bility of producing the true sugar cane (*Saccharum officinarum*) in this State. Unquestionably, it will thrive in some parts of the State if proper soil and moisture conditions are secured. In order to determine these points, we have secured through Director Stubbs, of the Louisiana Experiment Station, where special attention is being paid to the cane-sugar industry, cuttings of cane of a variety most likely to succeed in this State. These cuttings may be treated and planted as recommended for cassava cuttings above, using two or three joints to a cutting. As cane is heavy the charge will be 25 cents per package by mail.

CEREALS.

Although much interest is always manifested in the public exhibitions, which are occasionally made, of the large collections of cereals which are grown at our Stations, there does not seem to be very wide disposition toward individual experimentation with new varieties. The grain crops of the State consist of a few varieties, which have disclosed local adaptations, and seem to satisfy the growers. It should, however, be borne in mind that cereals are being improved by crossing and by selection, and we desire to secure experimenters in different parts of the State to determine whether alleged improvements are locally valuable or not. We offer the following:

New French Wheats.—Two French hybrids (Hybrid Dattel and Hybrid Lamed) were received last winter through the United States Department of Agriculture. They are good plump wheats, and are the result of crossing other varieties which possessed individual excellence either in straw or grain. Though, as we judge from the reports of Eastern Stations of the crop of 1891, they do not seem to be well adapted for Eastern conditions, they may be valuable in this State, where conditions are more like those under which they were developed. As grown on the Station grounds in Berkeley, they were quite satisfactory in growth and yield. We would like to have them more widely tried.

Berkeley Hybrid Barley.—A chance hybrid which originated at this Station, having a slender, leafy stem, and beardless. Especially commended for hay.

Rust-proof Oats.—Two varieties obtained from Georgia. The "Heavy Winter" is commended to us as a heavy, tall oat, which resists rust if sown early. "Mox Rust-Proof" very seldom shows any injury from rust, grows to medium height, and is very productive. It is counted in Georgia as the "surest and only reliable spring oat."

Terms for Cereals.—Applicants for seeds of the cereals named above may order any one or all varieties—15 cents for each variety in 1-pound sacks, postage paid.

SHRUBS AND TREES.

Though the following have been included in previous distributions, the demand for them seems to be constant, and they are again offered:

Osier Willows.—Nine named Austrian varieties; sent in lots of ten of a kind, 10 cents per lot; or one dozen assorted, 20 cents by mail.

English Oak (*Quercus robur, var. pedunculata*).—Of exceedingly rapid and satisfactory growth in California; commended for planting in most parts of the State, both upon lawns and in forest plantations. We send acorns, which should be planted at once where trees are desired, and pro-

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tected from birds, squirrels, and other animals. Packages of acorns, 10 cents each by mail.

Black Wattle (*Acacia decurrens*).—This tree has demonstrated its adaptation to most California climates, is a rapid grower, and very desirable. The seed should be put in boiling water and allowed to stand and cool twelve hours before planting; otherwise the seed may not germinate until the second year. Three cents per packet by mail.

Mulberries.—Cuttings of the following kinds can be had: Multicaulis, Alba, Russian, Downing's Ever-bearing, Lhoo, Nagasaki. Sent in lots of ten of a kind, 10 cents per lot; or twelve cuttings assorted, 20 cents by mail.

Resistant Grapevines.—These vines are not desirable for fruit-bearing, but are offered to those desiring to test them as stocks for grafting. Cuttings of thirteen species of *Vitis* can be had. Sent in lots of ten of a kind, 10 cents per lot; or a dozen assorted, 20 cents by mail.

Fruit Tree Scions.—The University orchard contains upward of five hundred named varieties of fruit, and our report on "Agricultural Experiment Stations," 1890, pages 182 to 187, contains a full list. This report will be sent to all applicants who may order any of the varieties named. We may not be able to supply all applications for some of the newer varieties, because the trees are small.

We do not furnish rooted trees, but scions, for grafting. We do not send large quantities of any variety, because the object is to test varieties and not to furnish material for commercial propagation. Send 10 cents for each dozen ordered of a single kind, or 20 cents if a dozen of assorted varieties is ordered.

FIBER PLANTS.

Ramie, ten plants, 25 cents.

Cotton, 8 ounces seed, 10 cents.

Jute, 4 ounces seed, 5 cents.

Flax, 8 ounces seed, 10 cents.

New Zealand flax, five plants, 25 cents. The plants are too large for mailing, and will be sent by express, charges to be paid by receiver; our charge is for packing.

Esparto grass, ten plants, 25 cents.

VEGETABLES.

Ceylon Pea.—This variety of table peas was received by us from Ceylon; its true varietal name not being known to us. It has proved a very productive and desirable late pea, and is worthy of wide trial. Sent by mail; 4-ounce packages, 5 cents.

Beans.—"Tall Mont d'Or," an excellent variety; 4-ounce packages, 5 cents.

Beets.—"Eclipse" and "Osborn," very early and excellent; 1-ounce packages, 3 cents.

Spinach.—New Zealand (*Tetragonia expansa*); described by Von Mueller as a good culinary herb and as useful for restraining drifting sands; growing even during severest heat and drought. Seed in 1-ounce packets, 3 cents.

Carrot.—Yellow Imperial; 1-ounce packages, 3 cents.

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DONATIONS OF SEEDS, PLANTS, ETC., DURING THE YEARS 1891 AND 1892.

1891.

From United States Department of Agriculture, Washington, D. C.: Grapes: Askaree, Alhakahee, White Shahanee, Charooshe, Hutal, Dizmar, Kahllilee, Black Shahanee, Rish Baba, Paykanee Razukee, Shiraz.

From Diamond Grape Company, Rochester, N. Y.: Twelve grapevines.

From E. E. Myer, Mare Vista Vineyard, Santa Cruz, Cal.: Syrian or Palestine grape, cuttings of Precoce de Malingre.

From Count Giuseppe de Rovasenda, Piedmont, Italy: Grape cuttings of Neretto grosso canavese, Colatamburro di Bitonto, Antibo, Malvasia Rovasenda, Negro amaro, Favorita or Vermentino di Liguria, Tadone, Bellino, Pelaverga, Croetto or Moretto, Bermestia violacea, Torok goher, Chenin, Zinzillosa, Malvasia di Brolio, Corbeau, Cenanese nero, Cipro, Pis de chêvre blanc, Lambrusco di Sorbara, Quagliano, San Gioveto, Barbarossa di Finalborgo, Neiretta, Vernaccia sarda, Nebbiolo di Dronero, or Bolgnino, Monica, Erbalus di Caluso, Danugue, Trivoti, Negro dolce, Croattina, Malvasia della Cartuja, Cipro nero, Catarattu a la porta, Mammolo toscano, Olivette de Cadene, Aspiran noir, Negrara di Gattinara, Grisa di Piemonte, Neretto di Cucceglio, Picpoul, Crujidero, Persan, Passaretta, Pagadebito, Ocru di bove.

From Professor Pulliat, Ecully (Lyons), France: French grape cuttings: Persan noir, Pis de chêvre blanc, Raisaine, Agostenga, Calabrese, Chasselas Coulard, Trebbiano, Bellino, Dodrelabi, Boudales, Malvoisie jaune du Piémont, Madeleine Royale, San Antoni, Lignan, Shiradzouli, Muscat Hamburg, Portugais Bleu, Frankenthal, Clairette, Semillon.

From C. M. Silva & Son, nurserymen, Newcastle, Placer County, Cal.: Newcastle apricot, Bridgetas French, Wonderful peach, Albright Cling, Lovett's White, Rostrarum Bigarreau cherry, Murdock's Bigarreau cherry, Date palms, Dollar strawberry plants.

From O. S. Chapin, Poway, San Diego County, Cal.: Natal plum (*Carissa grandiflora*).

From B. M. Lelong, San Francisco: One hundred apple trees on aphis-proof roots, from E. & W. Hackett, Adelaide, South Australia.

From R. Pecori & Co., nurserymen, Florence, Italy: Olives: Corregiolo, Bella di Spagña, Leccino, Piangente, Morinello, Santa Caterina, Infrantoio, Ascoli. (If it is the true Ascolana, or Oliva di San Francesco, the fruit should be the largest of all olive varieties. It has been known to grow nearly to the size of walnuts.)

From F. A. Gould, Santa Barbara, Cal.: Olives: Cucca, Morchiaio, Palazzuolo, Morinello.

From United States Department of Agriculture, Washington, D. C.: Willows: *Salix viminalis*, *S. alba casteriana*, *S. viminalis* (French), *S. amygdalina canescens*.

From H. A. Amoore, San Francisco: Plant of *Myrica rubra*, from Japan.

From E. & W. Hackett, seedsmen, Adelaide, South Australia: Wheat sample.

From United States Department of Agriculture, Washington, D. C.: Three varieties of wheat, Chinese potato bulblets, early orange; Link's Hybrid, Early Amber, Coleman, and Folger's Early sugar-cane. Henbane (*Hyoscyamus niger*), opium poppy (*Papaver somniferum*), Aconite (*Aconitum Napellus*), *Colchicum autumnale*, Belladonna (*Atropa Bella-*

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donna), rhubarb (*Rheum officinale*), *Lathyrus sylvestris* (a new forage plant), *Andropogon Hallii*, and three varieties of flax.

From Professor Greene, Berkeley, Cal.: Seeds of a palm of the South Sea Islands, and *Quercus lobata*.

From F. H. Boyd, New York: Seed of yucca and dasylirion, from Mexico.

From Carter, seedsman, London, England: Wheat samples: Birdproof, Pride of the Market, Millers' Delight, Stand Up, Hundredfold, Flourball, Carter's Peach, Holborn Wonder.

From Chas. H. Shinn, Niles, Cal.: Seed of *Cereus giganteus*, from Arizona.

From Steele Bro. & Co., Ontario, Canada: White Chaff wheat and carrot seed.

From F. E. Clotten, London, England: Flat pea (*Lathyrus sylvestris*).

From Ingegnoli Bros., Milan, Italy: *Trifolium repens*, or Bianco Lodigiano.

From S. Ephraim, San Francisco, Cal.: Ramie from India.

From Kinton Stevens, Santa Barbara, Cal.: Seed of "Chayote."

1892.

From United States Department of Agriculture: Sitka spruce (*Picea Sitchensis*), Lawson cypress (*Chamæcyparis Lawsonia*, Parlat), Lodgepole pine (*Pinus Murrayana*, Bulf.), Western white pine (*Pinus flexilis*).

From J. Heinsohn, Phœnix, Arizona: White beech (*Carpinus betulus*); red beech (*Fagus sylvatica*).

From Henry Melde, Eureka, Cal.: Perennial bean.

From Vice-Consul Santa Maria, Medellin, United States of Colombia: Seed of *Aristolochia grandiflora;* seed of *Corimo crespo*, a tropical tree.

From Kimball Bros., National City, Cal.: Persian grapevine cuttings: Askree, Rish Baba, Khallilla, PayKanne, Razakee, Dizmar, White Shahannee, Hutab, Chavoshee, Alhaklee, Black Shahannee.

From California Nursery Co., Niles, Cal.: 500 seedling olive trees of "Rubra."

From Dr. Warder: Grapevine cuttings: Marie Louise, Emma, Theophile, Bertha, Illinois City.

From H. Smetzer, Van Buren, Arkansas: Smetzer's Early No. 2 strawberry.

From Bauer Bros., West Lawn Fruit Farm, Judsonia, Arkansas: Strawberries.

From United States Consul-General to Calcutta, India, S. Merrill, Jr., through the Agricultural and Horticultural Society of India: *Amherstia nobilis, Bassia latifolia, Bougainvillia spectabilis, Brownia ariza, Camphora officinarum, Petræa volubilis, Poinsettia pulcherima;* grafts of *Mangifera indica* (Bombay mango) and *Mangifera leugra, Anona squamosa* (custard apple), *Achras sapota, Eugenia jambos* (rose apple).

From Maryland Station, United States Division of Forestry: *Quercus suber* (cork oak) seedlings.

Plants from Samoa, through Wilkins & Co., San Francisco; several tropical trees (Taliatree).

From the Mexican Phosphate and Sulphur Co., Sobrante, Cal. (H. M. Newhall & Co., Agents, San Francisco, Cal.): 2 bags dissolved guano, 1 bag guano flour, 1 bag brand "D," 1 bag brand "C," 1 bag dissolved guano, to be used on grasses.

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	July.		Aug
BAROMETER. (In inches.)			
Mean barometer for the month	29.928		29.940
Highest barometer for the month	30.086	9th, 2 P. M.	30.077
Lowest barometer for the month	29.781	1st, 2 P. M.	29.831
Monthly range	.305		.246
Highest daily average	30.064	9th.	30.016
Lowest daily average	29.800	1st.	29.858
THERMOMETER. (In degrees Fahrenheit.)			
Mean temperature of the month	61.6		62.9
Mean temperature of the warmest day	70.7	4th.	75.0
Mean temperature of the coldest day	57.4	7th.	57.4
Maximum temperature	87.5	4th.	93.4
Minimum temperature	49.3	7th.	51.0
Monthly range	38.2		42.4
Mean lowest temperature for the month	54.6		56.0
Mean highest temperature for the month	74.1		74.5
Greatest daily variation	34.5	4th.	31.0
Least daily variation	8.5	10th.	8.5
Mean daily range of temperature	19.5		18.5
PRECIPITATION. (In inches.)			
Rainfall during month	.440		
Rainfall since July 1, 1891	.440		.44
Rainfall during same period of previous year			
Dew and fog—total			
RELATIVE HUMIDITY. (Per cent.)			
Mean relative humidity of the month	80.0		81.5
Highest humidity for twenty-four hours	91.5	10th.	92.5
Lowest humidity for twenty-four hours	62.7	5th.	66.1
Greatest daily variation	34.6	21st.	41.7
Least daily variation	7.4	10th.	5.6
Maximum humidity	94.3	9th, 7 A. M.	94.9
Minimum humidity	49.4	5th, 2 P. M.	48.4
Monthly range	44.9		46.5
WEATHER.			
Number of clear days	18		1
Number of fair days	1		
Number of cloudy days	5		
Number of foggy days	6		1
Number of days on which rain fell	2		
Number of mornings on which dew was seen	7		12
Number of mornings on which white frost was seen			
Number of mornings on which ice was seen			
WIND OBSERVATIONS.			
Description of prevailing wind	S.W.		S.W

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B. THE FOOTHILL STATION.

Five miles north-northeast from Jackson, Amador County.

By CHARLES H. SHINN.

Generally speaking, the work of the past year at the important Station of the Sierra foothills has been satisfactory, though the late rains made it difficult to work the soil properly, and washed some of the slopes. The roads have been repaired and grades improved, a new bridge built, gates, outbuildings, and the house repainted, and a great deal of careful work done to improve the appearance and usefulness of the place. More protection of walls of rock has been given to exposed banks. Culverts have been put in to carry winter water across roadways. A very complete, small propagation house has been constructed upon Station Hill, near the dwelling. Some needed alterations have been made in the house. A sign, "U. S. Experiment Station; conducted by the University of California," has been placed over the main entrance, and a United States flag flies on Station Hill. Notes upon the fig trees grown here will be found in the separate fig report.

THE ORCHARD.

During the planting season of 1891–92, the orchard was slightly increased, and some substitutions were made. The present planting season of 1892–93 is being utilized to begin a new orchard of representative varieties upon the light soil (decomposed granite). A number of new varieties of the fruits that have done best at the Station are also being planted on the red soil.

Peaches.—The peach orchard is beginning to bear, and justifies as complete notes as any department of the Station work. The Foreman, Mr. George Hansen, contributes a careful review of this division. He says: "The part of our plantation which most readily catches the attention of the visitor is the peach orchard on the red soil. It lies well to the eye, and allows a free view to be had over the whole slope of Reservoir Hill; every tree shows to advantage here. The slope faces south, is warm and easily cultivated, and consists of the rich, red soil which is to be found all through the Sierra foothills. The original plan, when the Station was established, was to alternate rows of trees budded on peach with those budded on Myrobalan stock. As the Myrobalan stock arrived at the Station as dormant buds, and the ground was rough and newly cleared, the dormant eyes either died or made such a poor growth that they have never been able to catch up with the rest. The prominent trees are all on peach stock, and their growth is of such vigor that it is evident that the peach root is first rate for the soil and locality. The trees when set out were like any nursery stock—no better, no worse—all one year old, except, as I said, the dormant buds. The first season

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brought a very serious looking gum disease all through the orchard. It seemed, in fact, as if the trees were going to bleed to death. In spite of this they recovered the second year and made good growth. They never showed any further sign of the gum trouble. The third year brought abundance of fruit buds. But I believe in raising a tree before weakening it with fruit bearing, and so I gave up the pleasure of picking fruit. No tree was allowed to bear, and if any bud opened to the sunlight it was nipped before it set. The fourth year the trees were allowed to carry some fruit."

Peach Orchard Results, 1892.

Variety.	In Flower.	Fruit Ripe.	Number of Fruits.	Weight, in Pounds.	Remarks.
Alexander	Mar. 18	July 6	20	6	Best early peach.
Amsden	Mar. 20	July 8	21	5	Small here.
Albright's	Mar. 16	Aug. 30	11	3	Large fruit; quality high.
Beer's Smock	Mar. 15	Sept. 24	29	5½	Improvement on common Smock.
Bilyeu's Late	Mar. 16	Oct. 27	16	4	Fruit cracked badly.
Briggs' Red	Mar. 17	July 9	27	7½	Excellent quality.
California	Mar. 11	Sept. 3	54	11½	One of the best clings.
Chinese Cling	Mar. 8	Aug. 17	15	4½	Blossom handsome.
Coolidge's Favorite	Mar. 16	Aug. 14	10	3	Sweet; high flavor.
Columbia	Mar. 13	Sept. 20	198	41	Admirable for family use.
Crawford's Early	Mar. 17	Aug. 15	263	47	Allowed to carry more fruit than others.
Crawford's Late	Mar. 17	Aug. 29	18	4½	Small tree.
Crimson Beauty	Mar. 16	Sept 26	29	6½	A fine white cling.
Early Albert	Mar. 19	Aug. 16	22	4	Not equal to American early sorts.
Early Rivers	Mar. 17	July 23	138	30	Poor color; stone splits.
Elberta	Mar. 15	Aug. 30	32	9½	Splendid fruit; very firm flesh for free.
Foster	Mar. 14	Aug. 13	151	23	Bore too much for the tree.
Geary's Hold On	Mar. 15	Sept. 22	62	14½	Good late yellow free-stone.
General Bidwell	Mar. 12	Oct. 26	14	3	Cracks before ripening.
Governor Garland	Mar. 19	July 14	17	5	Good quality; semi-free-stone.
Grosse Mignonne	Mar. 17	Aug. 14	76	16	Old variety; does well here.
Hale's Early	Mar. 12	July 27	35	7	Not very promising.
Heath's Cling	Mar. 16	Sept. 25	44	8½	Not sufficiently thinned.
Henrietta	Mar. 17	Sept. 27	164	42	One of the best.
Honest Abe	Mar. 17	Aug. 30	89	16½	Too many twin fruits.
Indian Blood	Mar. 18	Sept. 9	126	19½	Not thinned enough.
Jennie Worthen	Mar. 21	July 7	32	9	Illinois peach; fair quality.
Lemon Cling	Mar. 12	Sept. 2	133	37	Does well.
Large White Cling	Mar. 15	Aug. 24	18	3	Not thinned enough.
Large Early York	Mar. 19	Aug. 14	27	5	Not thinned enough.
Late Admirable	Mar. 17	Sept. 5	50	10	Very good.
Lovell	Mar. 15	Sept. 3	24	6	Fine California seedling.
Mary's Choice	Mar. 12	Aug. 29	5		Poor.
Mountain Rose	Mar. 15	Aug. 15	4		Another poor sort.
Mrs. Brett	Mar. 9	Sept. 1	37	8	Very agreeable acid.
Newhall	Mar. 15	Aug. 30	442	71	Too heavy crop for tree.
Newington Cling	Mar. 16	Sept. 8	211	31	Too heavy crop for tree.
Nichol's Orange	Mar. 14	Sept. 4	33	7½	Excellent quality.
Old Mixon Cling	Mar. 14	Aug. 26	81	19	Excellent quality.
Runyon's Orange Cling	Mar. 15	Aug. 28	6		Excellent quality.
Salway	Mar. 14	Sept. 25	6		Excellent quality.
Shumaker	Mar. 19	July 12	24	6	Poor.
Smock Late Free-stone	Mar. 15	Sept. 24	47	7½	Excellent quality.
Strawberry	Mar. 15	Aug. 12	47	10	Recommended for family orchard.
Stump the World	Mar. 16	Sept. 6	139	31½	Fruit lacks juice.
Thissel's White	Mar. 16	Sept. 20	27	4½	Very poor here.
Tuscan Cling	Mar. 17	Sept. 23	36	7	Not desirable.
Wager	Mar. 19	Sept. 29	74	30	The best late free-stone.
Ward's Late Free-stone	Mar. 17	Sept. 23	36	7	Not desirable.
Waterloo	Mar. 18	July 10	13	3	Too small here.
Wheatland	Mar. 13	Aug. 28	52	15	Excellent.

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All the peaches noted in the above table were grown without irrigation. All were nominally four years old, but when first planted on rough hillsides made slow growth, and some of them are only as large as valley two-year-olds. In about every case there were only a few fruits allowed to remain. The stock was peach in every case, except Early Albert, which was on Myrobalan.

The comparatively small size of these "first-crop" peaches is partly due to the unusual dryness of the past summer. It is balanced by the unusual flavor and high color of fruit grown thus without irrigation, and another year the size will improve. Mr. Hansen writes: "When exhibiting at Ione (during our District Fair, September 27th) the sixteen varieties, which were in good condition at that time, it was acknowledged that our peaches excelled in color and flavor those from the valley. The few ranches which engage in fruit growing in Amador County are all more or less watered. The George's Late Cling, from ranches below, were nearly white, while every one of ours was flushed with rich color."

A study of the time of flowering is instructive. The middle of March was the average period, or rather the four days from the 15th to the 19th. But the Chinese Cling, which ripened August 17th, blossomed March 8th, the earliest of the fifty-one varieties. Mrs. Brett, a late peach (September 1st), blossomed March 9th. On the other hand, most of the early peaches—Alexander, Amsden, and Jennie Worthen, ripening July 6th, 7th, and 8th—were in blossom from ten to thirteen days later. The increased safety from frost secured by varieties that blossom so much later is evident. Among the main crop peaches, Governor Garland, Shumaker, and Wager are nearly as late in blossoming as the earliest varieties.

The new peaches sent to the Station since my last report include many desirable seedlings, and the best of the recent importations. Among them are the following: S. G. French and Red River, Oregon seedlings; Ellison, Leopard, and Chair's Choice, large yellow market peaches; Baldwin's Late, said to hang on the tree till Thanksgiving Day; Austin, a fine yellow cling, originating at Winters; Burke, a very large white cling from the south.

Apples.—In this district the apple has a distinctly profitable future. The range of varieties is greater than in the valleys; there is little or no disease, and the quality of fruit, judging from old orchards in the region, is certain to be high. Among the new varieties planted here since the last report are the following: Ingram, a California seedling; Everbearing, a yellow summer apple, three months in season; Stephen's "Rareripe," and Wytha, two new varieties of promise; Lankford, large, red, and a late keeper; Marshall's Red, a noted Napa County seedling; Yellow Transparent, a superior winter apple, of the Maiden Blush type; Mann, a very late keeper, of the Rhode Island Greening type; Nero, a very beautiful red and yellow apple; Haas and Hurlbut, new autumn apples of promise. In a year or two more, the apple orchard will require a very full report.

Pears.—The Japanese seedlings continue to show marked advantages as a stock. The pear trees are nearly all upon the slopes of Reservoir Hill. Trees healthy, and some will probably begin to fruit a little next season (1893). So complete an assortment of pears was sent from the University orchards when the Station was established that there is little need for any extension, except that some trees should be planted on the

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granite soil. Among the new sorts planted are: Osband's Summer, a fine and fruitful variety; Counseiller de le Cour, a large pear ripening after Beurré d'Anjou, and Cole, which is large and wholly seedless.

Plums and Prunes.—All the plums and prunes are in good condition, the few failures from dormant buds having been replaced. The Japanese plums continue to deserve recommendation for the mountain rancher's little fruit garden, and for hedges, from which a large amount of excellent fruit can be gathered.

The new plums sent to the Station include several California seedlings, and the new Normand's Japan. The most promising of the plums sent is Uncle Ben, a Stanislaus County seedling of Mr. B. H. Crow. The fruit is described as large, nearly round, pale yellow, and of excellent quality. Keeps "till nearly Christmas." Much is expected here of the noted Napa Valley seedling, Clyman. Stark's Green Gage is a highly recommended new plum, not yet generally distributed.

The list of new prunes grows larger every year, and it seems necessary to divide them into sub-classes, either as "yellow, red, or dark," or as "acid or sub-acid." The Elmore, which originated in Shasta, is said to be "a month earlier than any other sort," a valuable quality if the flavor is maintained. The Oregon Golden comes highly recommended. The Ruby, a dark red prune from Lake County, is probably well adapted to the Sierra foothills. Diamond, a "large purple plum," is considered an acquisition as a shipping fruit. It is rather more of a plum than a prune. It probably belongs to the same class as the Courtland seedling "Tragedy," which is early, and an excellent and profitable variety for shipping fresh.

Apricots and Nectarines.—The apricot and nectarine orchards are in good condition. There are no new nectarines of importance, and no California seedlings, as comparatively little attention has been paid to this fruit. Among the new apricots sent to this Station are Emperen, a very early sort imported from France; the shipping apricot, Boulbon, and several California seedlings of especial merit. One, Smith's Triumph, of Vacaville origin, is said to be as large as the Moorpark, ten days earlier than the Royal, and a good bearer. The Gooley apricot, another Solano County seedling, and the Flickinger, a Hemskirk seedling grown at San José, are also among the additions to the apricot orchard.

Almonds.—The almond trees grow fast and may do well, if the blossoms are not touched by frost. Lewelling's Prolific, Routier's Twin, and Drake's Seedling have been added to the orchard. Hard-shell almonds are in some of the old mountain orchards in the region, and a few so-called Languedoc soft-shells, said to have borne well when young and before they were neglected.

Cherries.—The cherry continues to be one of the successes of the place. There is evidently no trouble in similar districts in growing the cherry on a commercial scale. The fruit may be canned, shipped, or dried so well that its culture is recommended. A large area of the red foothill lands could profitably be planted to this excellent fruit. Among the new cherries sent to this Station was Major Francis, a large early cherry of the Black Tartarian type. The leading California seedlings are already growing here. The best grown trees are on a southeastern slope, red soil, sheltered by the Station Hill.

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GENERAL VIEW.

The work of the Foothill Station continues to grow in importance. Amador, an old mining county, long retrograding, as all the other mining counties of the Sierra retrograded after the exhaustion of the gold placers, witnessed many revived industries as the quartz mines were developed, and is now entering upon a permanent agricultural prosperity. The region in which the Experiment Station is situated is fairly and fully representative of a very large acreage in the Sierra foothills, extending across many counties, and presenting many serious problems to the agriculturist.

Like nearly all the old mining districts, the mountain valleys of central Amador about the county seat, Jackson, illustrates the early horticulture and the capabilities of the region. Old orchards of the leading deciduous fruits still stand in the midst of pastures; old vines of Mission grapes climb over the ruins of miners' cabins; old fig trees ripen their fruit for the quail and rabbits. Large, healthy trees one finds in such deserted orchards, and they are proof, if any were needed, of the horticultural value of the higher foothills. From such mountain orchards seedling apples, pears, and peaches of new and promising sorts have been introduced, and others of value doubtless remain that are worth testing under more favorable conditions. In the town of Jackson, at Jackson Gates, and on several ranches within four or five miles of the county seat, as well as at several points on the stage road from Jackson to Ione, are these typical old orchards, planted forty years ago. The whole foothill country of the Sierra, from Tuolumne to Shasta, contains similar beginnings, now neglected and forgotten.

Now, the work of the Foothill Station is to aid the people of this great mountain region to develop the horticultural industries most suitable to soil and climate. The olive, grape, and fig are at home here; so are the peach, apricot, nectarine, prune, and walnut. The range of possibilities is large and interesting. The district is a part of the extensive territory that the most thoughtful Californians have long looked upon as certain to attract the attention of home-seekers, and to become a land of orchards and gardens. Famous fruit growers and horticulturists in Butte, Tehama, Nevada, Placer, El Dorado, and other counties, are working under conditions similar to those of the Foothill Station, and the experiments there cannot fail to be of service. The testing of vegetables, small fruits, orchard fruits, cereals, forage plants, and a great variety of small cultures, all with especial reference to their adaptability to the Sierra foothills, is one of the most practical and immediate objects of the work in hand.

The isolation of the Station tract has certain advantages. Five miles from the county seat, and a mile from the nearest highway, shut in by almost impassable roads in winter, and only reached at any season by a hard wagon ride after several hours in the stage from Ione, the Station is in all essential particulars a mountain ranch devoted to experimental purposes. It has very great natural beauty, which the Foreman, Mr. Hansen, appreciates and has preserved and heightened by his paths, roads, clearings, and ornamental planting. The native growth is particularly representative of the flora of the district, and the finest trees of every species remain. The range of soils includes the two prominent soils of the district, in several combinations. In the course of time the

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orchards and various plantations will be extremely picturesque, as well as interesting to the horticulturist. But the chief thing to be remembered in connection with the Station, its especial and peculiar value to the people of California, lies in the general farm problems that it seeks to solve for those whose homes are or may be in similar situations. More than the valley stations, the Foothill Station must be a model farm, in all the completeness of the phrase. It has hardly any visitors, for its isolation is such that few farmers from other parts of the State find their way there, hence the time and means at our disposal can be more thoroughly devoted to the department of work which can be reported for the public benefit, rather than to those cultures which frequent visitors desire to see. The only means of reaching the farmers of the State, that are open to the workers at the Stations, are by letters, printed reports, and exhibits at the various fairs. The other Stations, in the Chino Valley, at Tulare City, and at Paso Robles, have, in addition, the constant coming and going of representative farmers, fruit growers, and persons who are interested in Station work. In Amador, neighbors and townspeople drive out for the view, or picnic on the adjoining ranch, but visitors in the sense of students, the Station does not have.

A little observation of the needs of the Sierra foothills will further strengthen the position that this mountain ranch, now devoted to experiments, has a very important work to perform. The vegetable garden has a special significance here, where there is no village supply and no peddler going to any farm. Every mountain farmer desires to know the best varieties to plant, and the best culture to give. Eastern experience and that of the lowlands is often misleading; the foothill men must make their own experiments. Mountain-grown vegetables, in many districts, have a commercial future, and the field for investigation is very broad. Small fruits are still more attractive, and full of promise for the future. The larger orchard possibilities must not be ignored nor forgotten, but those things which belong to the complete and self-sustaining mountain home are valuable in an at least equal degree. In order to fulfill this general scheme, the area secured for the Foothill Station was larger than at any of the other Stations, and the expense of carrying it on is in many respects greater, but it is believed that the results will be of benefit to many farmers who are not indirectly interested in the work of the lowland Stations. Nor will these results be limited to the Sierra foothills; they must also help isolated farmers in all the hill regions of the State.

HAY-GROWING IN THE SIERRA FOOTHILLS.

By Geo. Hansen, Foreman of the Foothill Station.

This year, in our hay-growing, we used the seed which we had saved the year before. The foothills are never looked upon as a grain-growing country; we are thankful when we produce all the hay we need, and pride ourselves upon the excellent quality of our crops. The greater part of all the seed sown here is brought up from the valley.

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FERTILIZER EXPERIMENT.

The Sierra foothills have no level and square ranches, as in the valleys; we have to pick a favorable spot wherever we can find it. That is the reason why I used last year's experiment plots in just the same way and shape. I therefore refer to the previous report (1891, page 277). We equalized the amount of fertilizer, adding nitrate of soda where only bone meal had been used in 1891, and the latter where only the former had been applied, giving superphosphate to all plots which did not have it before. As Professor Hilgard said, in his summing up, the amounts of one, as well as the other, were used rather excessively in 1891, but we had to consider the heavy rains, which not only soak, but wash out and carry away much of the soil. This is one of the reasons why cultivation here is much more expensive than in the valley.

It is difficult for a valley farmer to understand why barley hay is quoted in the mountains as higher than wheat hay; he cannot get such prices in the valley. Here one cannot sell wheat hay as long as barley hay is in the market, and if he does sell it, it is at a lower figure. Wheat, up here, will grow in poorer ground than barley, and it gives a heavier crop besides. But the mountain horses, unless brought up on wheat hay, do not like it, and will keep in better condition on barley hay. If we feed good barley hay all the time, ordinary farm horses never need ground barley from one year's end to another. Teaming and logging horses, which, in summer, hardly have the harness off their backs, could not eat enough hay through the night to keep them in condition, and ground barley is fed to them by the sackful.

To find out, by actual experience, how much the difference of a crop of barley hay and a crop of wheat hay amounts to, I sowed the experiment plots in wheat this season. The result has been striking. The wheat brought about two thirds more hay than barley. Everybody around here knows that freshly cleared land, cultivated for the first time, raises a poorer crop than the same ground the next season. It must be remembered that the barley of last year was the second cut from that very ground, and, according to local experience, should have been extra good for this locality; but this wheat crop should have been behind the average, because I had only time to cultivate the seed in, being pressed with other work at the season.

We had three plots of half an acre each, and two of a quarter of an acre each. Plot No. 1 received 100 pounds of bone meal and 150 pounds of superphosphate, in addition to whatever was left of 225 pounds of nitrate of soda used last year. The yield of wheat hay was at the rate of 1½ tons an acre, an increase of about one third over the capability of unfertilized land. Plot No. 2, on which 75 pounds of nitrate and 150 pounds of superphospate were added to the 400 pounds of bone meal used last year, making a very strong fertilizer, yielded at the rate of 2¾ tons per acre. One of the small plots, treated with only 50 pounds of bone meal and 35 of nitrate, upon what was left of 125 pounds of Newhall's "C" fertilizer, appears to have given much the best results from any expenditure of the season; it yielded at the rate of 5,700 pounds of hay per acre.

Each plot was sown with 360 pounds of wheat, cultivated in December 9, 1891. The rainfall in the one hundred and seventy-three days between the time of sowing and the time of cutting (May 30th), was

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28.90 inches, distributed as follows: December, 7.16 inches; January, 2.79; February, 5.15; March, 5.99; April, 3.11; May, 4.70.

DIFFERENT VARIETIES.

As far as last year's crop of seed would reach, I have tried to find out how much hay a certain quantity of seed will grow. The place chosen was the other half of the granitic soil across the ditch, next to the fertilizer experiment spots (McKay tract). This half is in no part intermixed with red soil, but is rather richer in humus, on account of a very heavy growth of brush recently cleared off. It would have been idle to experiment further with the growing of hay without the aid of fertilizer on this soil. Using former experience with the fertilized plots, I treated the tract (two acres) to a dressing of 300 pounds of superphosphate, 200 pounds of bone meal, and 150 pounds of nitrate of soda, per acre. Owing to the shape of the tract, I could not sow plots of equal size, and I also note that the seed of some varieties is large and heavy, and therefore more of it is required on the same ground than of a small and light-seeded kind. I therefore used all the seed I had, and if it appears to the reader that I tried to crowd the seed on one plot, while using another kind rather sparingly, I must say that the best was done under the circumstances as a farm test. In the valleys thin sowing is often needed, and the stooling of the plant fully makes up for the scarcity of seed. In our district thick sowing is an absolute necessity. One hundred and eighty pounds of wheat to the acre is thought none too thick, and 220 pounds of barley is used. It is interesting to compare with this the less amounts used in my experiments. The difference between the price of additional seed and the cost of fertilizers will easily warrant the employment of the latter, taking into consideration the heavier crop of hay. Further experiments with the amount of seed used will determine the most profitable rule for this light soil. It seems to me that the facts presented below will serve as a beginning, and if round figures are used instead of the exact number of pounds harvested, the average result will stand for any soil of similar nature all over the foothills.

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Table of Production of Cereals Sown December 11, 1891.

Variety.	Seed—Pounds.	Area—Square Feet.	Average Height—Inches.	Average Head—Inches.	Days of Growth.	Hay Results.	Seed per Acre.	Hay per Acre.
WHEATS.								
Diamond (Polish)	1.50	552	51	4.00	179	50	118	3,950
April (fern)	1.50	552	56	3.25	181	55	118	4,345
Forelle	1.75	437	51	2.00	179	70	175	7,000
Frankenstein	2.75	759	49	3.50	175	59	156	3,363
Genoese	1.25	460	52	3.00	179	35	118	2,765
Greek Atlanti	1.50	552	58	2.25	176	35	118	2,765
Harris, from Jasper	3.25	1,357	52	2.75	196	75	104	2,400
Hungarian (Brenner)	2.50	850	53	3.00	196	82	127	4,128
Indian (three months)	1.75	552	50	2.50	183	57	189	6,156
Missoyen	1.25	2,001	51	2.50	181	60	92	1,305
Nonette Lousanne	4.00	1,357	55	1.33	181	155	128	4,960
Petali	3.25	1,196	45	2.25	197	88	117	3,168
Pringle's Defiance	3.25	805	49	4.50	200	70	175	3,780
Royal Australian	1.75	506	54	3.00	181	78	149	6,708
Russian Red-bearded	4.25	713	49	2.50	200	50	137	3,050
Victoria	1.25	391	41	3.00	194	28	139	3,108
Whittington	2.75	1,171	58	3.25	176	72	101	2,664
Yellow Noe	1.50	759	49	2.00	179	27	85	1,539
BARLEYS.								
Berkeley Hybrid	21.00	3,989	38	2.50	168	310	231	3,410
Black Six-rowed	2.00	736	46	1.75	169	46	118	2,714
Italian	3.00	966	51	2.50	169	62	135	2,790
Large Naked Two-rowed	1.75	598	39	2.50	168	43	128	3,182
Manchurian	3.00	1,104	46	2.00	168	65	118	2,567
Nepaul	1.25	299	37	1.75	168	75	181	2,175
Rice	3.50	1,334	38	2.00	168	50	112	1,600
Six-rowed Brenner	2.00	874	31	1.50	179	30	100	1,500
RYES.								
Excelsior	1.50	552	72	5.00	168	25	119	1,975
Perennial Saxon	2.25	1,081	70	4.75	175	120	95	5,100
St. John's Day	2.25	1,357	67	4.75	177	160	72	5,120
OATS.								
Bald	2.25	2,553	54	11.00	195	130	35	2,210
Black Tartarian	3.50	2,070	54	9.00	214	135	73	2,835
Canadian	1.50	989	65	12.00	206	138	66	6,072
Gray, from Houdan	5.00	2,875	40	8.00	201	224	57	2,576
Scotch Hopeton	2.75	1,061	61	10.00	206	97	75	4,122
Surprise	1.50	851	67	12.00	203	105	76	5,355

Wheat produces a heavier crop than barley. Oats do a trifle better than barley, with less than half the amount of seed. Thus:

Barley, average of 8 varieties ..... 140 pounds seed; 2,493 pounds hay to acre.
Wheat, average of 18 varieties ..... 180 pounds seed; 3,763 pounds hay to acre.
Oats, average of 6 varieties ..... 64 pounds seed; 3,861 pounds hay to acre.

This speaks strongly in favor of oats. The varieties of rye were grown for comparison's sake only. Wheats, barleys, oats, and ryes were sown December 11, 1891. The rainfall during the growing season amounted to 29.01 inches.

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CLEARING LAND IN THE SIERRA FOOTHILLS.

By GEORGE HANSEN, Foreman of Foothill Station.

The low price of land in the Sierra foothills is offset by the expense of clearing the land when purchased. It would not be so bad if the cleared land would bring a price somewhere near the outlay. But such will not be the case as long as agriculture in the foothills consists of little except hay-ranching to supply the mountain teamsters.

Foothills here cannot be settled on the plan of 5 or 10-acre farms. There is too much worthless land. Some hillsides are too steep to allow of profitable cultivation; others have many rocky or barren streaks. A quarter section is none too much if the owner wants to engage in vegetable growing, fruit culture, and ranching. He needs besides that a tract to turn his stock upon, and woodland for firewood and other uses. The native growth on the hills is varied. It is pine and manzanita mainly, interspersed with oaks of many kinds. One man cannot undertake clearing by himself. He would never find profit in his labor. He needs help of other men and animals. As a rule, three men constitute a good clearing crew, assisted by a span of steady animals—little mules or horses. One man handles the team, another assists him, the third does the grubbing around the bushes and trees. We gave steel harness a fair trial last year while clearing, but do not like it; good as it is for plowing among trees, the horses cannot exert so steady and firm a pull as they are able to with leather harness. To the doubletree we attach by a ring a $1\frac{3}{4}$ or 2-inch rope, having at its other end a smooth, broad hook. The rope should be about 25 feet long, so as to tie around the brush and allow for shortening in case of wear. Pretty nearly all the brush can be pulled out by strong horses, and this method is the very best, as it removes most of the roots from the ground. Manzanita (*Arctostaphylos*) roots near the surface and is easily lifted, no matter how large the circumference of the bush. Chaparral (*Ceanothus*) grows deeper, but also yields to horse power. Now and then a blow with a grubbing hoe or ax may be required. Chaparral is the worst brush to handle, being nearly as stiff as barbed wire.

Of course this brush-pulling can only be done in winter. The best time is after the first heavy rains, as soon as the ground is dry enough for horses to get a good hold. The redberry (*Heteromeles arbutifolia*) is, in some ways, most awkward to remove. It has a knotty root under the surface, which gets larger with every year of growth. To get the rope underneath this knot is only possible after considerable digging, and by that time a few strokes with the mattock removes it about as easily. Smaller bushes, like the poison oak (*Rhus diversiloba*) or the Yerba Santa (*Erydictyon glutinosum*), have to be dug out, and deep enough to prevent them from growing anew.

Greasewood does not grow near Jackson. It is abundant in the lower foothills. It is easily cleared by chopping off the brush, any time in the year, and plowing up the little stumps when the ground is very wet. This work requires a strong team and a man who does not mind being thrown every way by the handles of his plow.

Pines are troublesome. If young and slender they may be pulled out. But nearly every one requires digging around the root. Horses are of great service after some digging has been done, for the stem can be bent

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over and the tap root may then be cut. If pines are plentiful on the land, it would not pay to dig them out. They should be cut close to the surface. If done in early spring, when the sap begins to move, the roots will rot in from two to four years, according to the size of the tree. A rancher will probably find it cheaper to let the roots of pines rot in this way than to dig them out.

Oaks are expensive to clear. With the exception of the white (*Q. lobata*), and the white live oak (*Q. chrysolepis*), all will grow again if cut above the ground. The worst species is the black (*Q. Kelloggii*), and the black live oak (*Q. Wisliceni*). The species grow into a regular forest of shoots when the main growth has been cut down, and many a stump has been found with a mass of shrubbery 9 feet in diameter, resulting from the young growth coming up around a tree cut down many years before. The clearing of oaks has to be done through digging. Little oaks may be pulled out, providing the soil is very friable, but if they have anything like a hold in the ground, the horses will only get a few branches. Big oaks should be cut and their roots laid bare. Every shoot can be kept down if a man chops them down several times during the summer. This method will kill the tree's life before long. The following autumn, before the rains, fire should be set to the stump. If it will not take hold, and no dry brush can be had to be piled upon it, it is best to split the stump by blasting, after which the shattered wood will catch fire easier.

The buckeye (*Æsculus Californica*) has a knot at the surface of the ground resembling the root of the redberry, but it is much larger, and cannot very easily be underdug. It is quicker and cheaper to use blasting powder.

Blasting has to be done in most cases when trees have to be removed. With pines it is best to bore an auger hole into the tap root when laid bare, fill it with powder, and light with fuse. As a rule, the tree will come down at once. Oaks have to be removed piece by piece, especially stumps that have grown in circumference after the old tree has been cut down. If blasting has to be done close to a building, it is necessary to cover the place with thick brush, so that if small rocks should fly up they would not have force enough to break anything. It is wise to remove everything on the ground at the same time, and it should certainly be done when the soil is to be used for fruit culture. But for hay-growing it is often cheaper to do the work part at a time. We have pulled out all that we could, piling it up at the same time, and burning it after a couple of weeks, when the wind and sun had had time to dry the brush. It will often burn without piling up, and all that is needed is to fork the larger stems into the coals. We cut the biggest pines close to the surface, and the logs, after having been cut in lengths, were dragged away. Middle-sized oaks were "trimmed high," so that the tree could not give much shade nor make sprouts at the bottom. Large stumps were exposed by digging, and remained thus until autumn, when they were burned.

The crucial question is, of course, the expense of the work. It is impossible to lay down a universal rule, but if everything has to be removed as the crew comes to it, $40 to $50 per acre is a fair allowance. The ruling prices for labor here are, team and man, $5 per day; the laborers ask $2 a day. Tools are provided by the employer. If the native growth does not require much digging, the price will be less. In

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most cases the one who has the clearing done will own and handle the horses. Then he can board the men, and will pay them only $1 a day. He can also do a good deal of clearing when other work is not so pressing. That is the best way for a pioneer. When he has obtained a ranch by such hard work he will be one of those who have some energy to spare for the rest of the country, and to aid the development of the fertile foothills, destined some day to become one of the best parts of the State.

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C. SOUTHERN COAST RANGE STATION.

One and a half miles north-northeast from Paso Robles, San Luis Obispo County.

By CHARLES H. SHINN.

This station, which represents hundreds of square miles of foothill lands in the Coast Range, is necessarily of much importance. Soils similar to that of the Station tract are found in many counties, and many places have also a similar climate. It is upon land that only a few years ago was considered worthless except for pasture, but that is now almost surrounded by grain fields. It was formerly occupied only by sheep-herders and cattle men. The region is subject to frosts, and the summers are hot and dry. Rainfall is sometimes so light that only the most thorough tillage keeps trees and vines in health.

THE ORCHARD.

There is little to report, except along the lines indicated by last year's report. Apples, pears, peaches, almonds, and cherries are making good trees, though the soil should be heavier for some of them. The adobe in the rear of the tract and in the low swale crossing is the best pear land, and when better drained will suit apples. Some of the apricots have a poor location. Nothing does well for a few years on the soil from which one of the large oak trees has been taken. Special fertilization is required to establish vines or fruit trees upon such spots, and they can be picked out at a glance over the tract.

Apples.—A good apple orchard will be obtained here with care. The White Winter Pearmain is the most thrifty grower. New varieties, including several Oregon and California seedlings, have been added. A new apple plot will be laid out upon the highest part of the adobe soil. The Foreman writes, under date of December 28, 1892: "I feel more pleased with the success of our apple trees than of any other trees of the orchard, because, when planting them, we had little local data to go on, and thought the climate too warm. A large variety was planted, in the hope that out of the number we might get a few of the thicker-leaved sorts to withstand the heat. With low pruning, shading the stems for the first two years, and keeping up cultivation, we have raised model trees. A few varieties bore fruit this year, and next year nearly all will bear."

Pears.—The demand for knowledge about shipping pears in this district is very great, and the list of varieties represented has been increased by some twenty choice new sorts, mostly unknown in California, and nearly all large and late keepers. The avenue down the center of the tract, which was laid out half way with mulberry trees and figs, is being extended to the rear of the tract by pears, two of a kind, except in the case of Bartlett, of which twelve have been planted, as the importance of this variety justifies especial experiments. The ground squirrels

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gnaw more pear trees than any other species in the orchard, and have to be poisoned and fought in every possible way.

The Foreman writes: "The pear orchard is one of the best features of the Station. We planted on a very heavy soil, and, the land being new, it was a hard job to get the trees started, but now they are growing excellently, and nearly all the sorts seem robust. None of them have fruited yet, but abundant evidence is to be had in the surrounding country that they will be a success. They are in perfect health, and the cool evenings so retard their ripening that they are solid to the core, and calculated to bear shipment to long distances. The Bartlett is the kind which is mostly planted in this district."

Cherries.—The trees are small, but of excellent style and hardiness. There is no reason to doubt the adaptation of cherries to many parts of the district. Some new California seedlings, such as Advance and Purity, have been added to the list. The Empress Eugenie, English Morello, and similar sorts fruit first here. They have nearly all borne a few cherries. Olivet yielded well last year. The cherry, as a rule, bears early in this county, and for a family orchard it is quite safe to plant, but for extensive commercial orchards the cherry belongs nearer to the coast. It sunburns readily, and most of the old trees in the county have suffered from not shading the stems. The cherry has not been nearly as extensively planted in the upper Salinas Valley as the prune and peach.

Apricots.—Better results on the granitic sandy soil, where some fine trees are observable. Adobe soil is too heavy and wet in winter for even the plum stock. A fine list of the new varieties has been planted on the more suitable soil. The apricot is more difficult to prune into shape here than in the valley, growing very unevenly; will do better when bearing begins.

Almonds.—King's Soft-shell bore a few nuts; so did the Nonpareil, Sultana, Harriot's Seedling, and Paper-shell. The I X L, and others, were frosted, and lost all their fruit. The season of 1893 will probably settle the question of climate, as regards fruiting; the soil suits the trees exactly. Several new California seedlings have been sent to the Station. The almonds are the strongest-growing trees in the orchard.

The Foreman reports as follows concerning the effect of frost on the almonds: "The trees were full of blossom this year (1892), and set a good crop; but the frost came late, and only a few escaped. We have the best varieties, and the trees all look well. With us they begin to bloom about February 14th, and have not seemed to vary for the last three years. Harriot's Seedling was the first in bloom. I was in hopes that the late-flowering varieties might escape the frost, but this year they all failed. A neighboring orchard belonging to Judge Cotton, in every way similarly situated, has a lot of almond trees, and I have seen several first rate crops on it. I can point to several orchards, not 3 miles from here, where the almond crop was all that could be desired, even this year, so it is evident that failure of crop was local. I am of the opinion that this county will yet be famous for its almonds, and there are miles of rugged hill land on the Santa Lucia range out of the frost's way—just the place for them."

Peaches and Nectarines.—Peach stock is certainly preferable. The list of peaches has been very greatly increased from many sources, as it is the intention to make the peach division of the orchard a very important

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one, especially in the hardier sorts much needed here. In some places the surface is so near the hard clay underneath that the trees have done but poorly. Some also seem to have been allowed to carry too much fruit for a first bearing year. But upon the whole, the peaches did well, and the Foreman, Mr. Cruickshank, made quite a display at the District Fair.

Nectarines were not largely planted. Most of the trees have done well, the exception being those on Myrobalan stock, which were planted on lighter soil than the rest. Last season most of the fruit dropped. The Foreman writes: "This fruit is held in higher esteem than the peach in the English market as a green fruit, and I think it could be gathered in a greener state than the peach for shipment to a distance. It generally does well over here, but is not so common as the peach.

Thirty-eight varieties of peaches are reported in the following table:

Variety.	No. of Fruits.	Time of Ripening.	Remarks.
Newington Cling	7	Sept. 18	Excellent and large.
Large White Cling	105	Sept. 15	Carried too many for tree.
Mrs. Brett	105	Sept. 1	Very fine; tree strong grower.
Old Mixon Free	65	Sept. 1	Fruited last year; excellent.
Grosse Mignonne	8	Aug. 28	Poor fruit.
Jennie Worthen	10	Sept. 18	Excellent fruit.
Nichol's Orange Cling	12	Sept. 10	Excellent fruit.
Wilkin's Cling	3	Sept. 14	Large and fine.
Lemon Cling	16	Sept. 10	Large and fine.
Muir	75	Sept. 5	Excellent; is much planted here.
Italian Dwarf	12	Sept. 28	Too dry for this variety.
Beer's Smock	12	Sept. 18	Only medium.
Late Admirable	10	Sept. 18	Excellent.
Crawford's Late	10	Sept. 1	Good quality.
Governor Garland	9	Sept. 2	Excellent.
Lovell	30	Aug. 28	Very fine.
Henrietta	12	Sept. 10	Poor quality.
Picquet's Late	15	Sept. 12	Small fruit.
Yellow St. John	6	Aug. 15	Quality excellent.
Runyon's Orange Cling	15	Sept. 18	Very fine.
Heath Cling	25	Sept. 1	Excellent.
Bilyeu's Late	25	Oct. 20	Good quality.
Susquehanna	6	Sept. 10	Poor.
Indian Blood Cling	12	Sept. 5	Small.
Stump the World	3	Sept. 12	Poor.
California Cling	6	Aug. 29	Very fine.
Salway	12	Sept. 10	Good.
Brandywine	6	Sept. 15	Good.
Wager	13	Sept. 6	Good.
George's Late Cling	50	Oct. 10	Very good.
Briggs' May	10	July 19	Very good.
Bonanza	60	Oct. 15	Extra fine.
Thissell's White	13	Sept. 10	Good.
Albright's Cling	4	Sept. 18	Good.
General Bidwell	20	Oct. 25	Good.
Honest Abe	12	Sept. 18	Good.
Shumaker	5	Aug. 10	Fine.
Grover Cleveland	6	Sept. 1	Fine.

The first thing to notice about these results is that some of the best peaches on the list are Pacific Coast seedlings, such as the California, Lovell, Runyon's Cling. The Susquehanna, a good market peach in Solano, does poorly; the Stump the World and Grosse Mignonne, both long in cultivation, the latter, indeed, a very old imported variety, are at the bottom of the list. Time of ripening ranges from July 19th (Briggs' May) to October 25th (General Bidwell). The first fortnight of September is the height of the season. Excellent late shipping peaches can b

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grown here. But there are also a number of varieties that failed to bear fruit. The following table should be studied in connection with the preceding one:

Peach Trees Not Fruiting in 1892.

Variety.	Cause.
Large Early York	Blossoms frosted.
Mountain Rose	Blossoms frosted.
Old Mixon Cling	Blossoms frosted.
McKevitt's Cling	Blossoms frosted.
Crimson Beauty	Blossoms frosted.
Hale's Early	Blossoms frosted.
La Grange	Blossoms frosted.
Wheatland	Blossoms frosted.
Foster	Blossoms frosted.
Wilkin's Cling	Blossoms frosted.
Honey Cling	Blossoms frosted.
Geary's Hold On	Blossoms frosted.
Ulatis	Blossoms frosted.
Strawberry	Blossoms frosted.
Crawford's Early	Blossoms frosted.
Alexander	Blossoms frosted.
Tuscany Yellow Cling	Blossoms frosted.
Seller's Cling	Blossoms frosted.
McDevitt's Cling	Blossoms frosted.
Royal George	Too near oak trees.
Newhall	Too near oak trees.

This is a surprising list, including, as it does, some of the earliest, latest, and most noted market varieties. The periods of severe cold during the spring of 1892 were as follows: Sixteen nights in January the thermometer fell below 34°; also, seven nights in February, five in March, two in April, and one in May. The lowest temperature was 30°, on March 28th. Here are twenty varieties that seem to blossom so as to be caught by the late frosts, but it will require another season's test to determine which must be discarded. There seems to be no reason why Alexander and Ulatis should be more tender than Briggs' Red May. Strawberry and Large Early York are said to be less hardy than the average, but Crawford's Early and Seller's Cling have hitherto borne a good reputation as regards hardiness. Time of blossoming will be put on record another season.

Plums and Prunes.—Among the new kinds added are six varieties of prunes not before represented, mostly seedlings of promise. Japanese plums continue to rank high for early bearing and heavy yield. Prune d'Agen has been planted more extensively for future experiments. Late shipping plums of all obtainable sorts have been sent to this Station, as the region is destined to become a famous plum district. A number of varieties can be expected to have fruit next season.

The Foreman says of the plums: "They are on the poorest piece of land we have, but some of them have made a marvelous growth, and are going to be a success. The frost took quite a number while in bloom, and we had only a few trees to bear this year. Those planted in the swale, which was under-drained with tiles, are doing splendidly, demonstrating the practicability of utilizing to good advantage the numerous hollows of these undulating lands. It was formerly impossible to walk over this place till about the 10th of April; now it is about the best land we have, and is being planted with trees on Myrobalan stock. We tried a few peach trees on it, on the Myrobalan, and they yielded fine large

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fruit the second year. I tried two cherry trees, and they have made a healthier growth than on the light soil."

So far the Myrobalan seems the best prune stock, although some on the apricot look fairly well. The Foreman writes: "I think the prune trees will exceed in number any other sort that has been planted out in this district. I must confess that I think people were not justified in planting so largely until they discover whether it really is a success. So far as the growth of the trees is concerned, it is, but I felt disappointed when I visited the finest-looking prune orchard we have about here and saw the smallness of the fruit."

Walnuts.—The hot sun of the summer of 1892 killed the Persian and English walnuts. The soil was poor where the walnuts were planted, and large oak trees take out most of the moisture. The only place for walnuts is on the lowest portion of the tract, and I doubt whether they will endure the dry heat of the summer even there. All the other varieties of walnut, also the pecan, hickory, and chestnut, have suffered greatly from sunburn. The California Black makes a fairly good shade tree.

Olives.—Nevadillo blanco, cut down by the frost in 1891, sprouted again from the roots, and suffered again in the winter of 1892. I am inclined to think that it is too tender for this locality. Atro-violacea is particularly hardy here. Oblonga, Rubra, Pendulina, and a few others in the collection are beginning to bear fruit.

Other Fruits.—Oranges are very small for their age; require much more water; suffer greatly from frost. Quinces have done badly. Japanese persimmons need moister soil. Figs are reported more fully in special paper. Station tract is too frosty for the fig; it does better in other parts of the county. Of mulberries, the Morus alba and Downings were both frosted badly early in October, 1892—the same frost that injured the fig orchard. Temperature was 26°, coming when trees were still growing.

THE VINEYARD.

The collection of grapes has been largely increased during the past planting season. The new Persian varieties, recent importations from Italy, a choice list of American hybrids, and a collection of *Vitis*, have now been added. The vineyard is a credit to the Station. At the Sixteenth District Fair, opened at San Luis Obispo September 17, 1892, the Foreman, Mr. R. D. Cruickshank, exhibited the following seventy-seven varieties, grown on the Station tract:

Verdelho.
Gros Mansenc.
Blue Portuguese.
Pinot de St. Georges.
Barbarossa.
Petite Sirah.
Johannisberg Riesling.
Tannat.
Chauché Noir.
Clairette Blanche.
Cabernet Sauvignon.
Chauché Gris.
Pinot Noirien.
Black Morocco.
Teinturier Mâle.
Affenthaler.
Nebbiolo Fino.
Spanna.
Carignane.
Pinot de Pernant.
Golden Chasselas.
Sérine.
Verdal.
Herbemont.
Gamay Teinturier.
Cabernet Franc.
Grossblaue.
Ploussard.
Franken Riesling.
Pedro Jimenes.
Steinschiller.
Grüner Valtelliner.
Sémillon.
Merlot.
California Malvoisie.
Huasco.
Bastardo.
Tinta Amarella.
Folle Blanche.
Crabb's Black Burgundy.
Palomino.
Tinta Madeira.
Malbeck.
Kleinberger.
Fresa.
Aramon.
Mourastel.
West's White Prolific.
Bonarda No. 1.
Muscatello Fino.
Gewürtz Traminer.
Burger.
Luglienga.
Ugni Blanc.

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Almeria.	Zierfahndler.	Blauer Burgunder.
Malvasia Bianca.	Gros Verdot.	Peverella.
Wälsch Riesling.	Grenache.	Petit Bouschet.
Nebbiolo Bourgu.	Aleatico.	Rothgipfler.
Ruländer, of Europe.	Charbono.	White Vernaccia.
Mission.	Mataro.	Muscat of Alexandria.
Purple Cornichon.	Cinsaut.	Robin Noir.
Meunier.		

GENERAL VIEW OF THE STATION.

The experiences of the past year show that commercial orchards of almonds, apricots, and prunes should be planted with caution in this variable district. Orchards at a greater elevation, on either side of the Salinas, did better than the Station orchard. On the west side the vineyards were untouched by frost December 20th, while the Station vineyard was severely cut back by the frost of October 16th. On the west side the vines were best on the top of the hills, and continued in fairly good condition down to within about 40 feet of the valley. The Muscat grape is a late ripener, and hardly has time to come to perfection in the lower districts here. The low night temperature, at the time of bloom, often causes it to set irregularly. Well-located vineyards of table grapes in the Upper Salinas are demanded to supply the coast towns, where grapes are not of as high quality.

Although the season of 1892 was so dry and cold, the orchard industries of northern San Luis Obispo County have greatly grown. In the districts of San Miguel, Paso Robles, and Templeton 150,000 trees were planted, according to the Inspector's report. Most of these were for little home orchards. Only one small lot were destroyed because of insect pests. The fruit prospects for the coming year are much better, there having been as much rainfall up to December 15th as the whole of the preceding season.

The especial work of the Paso Robles Station is as distinctly cut out for it as the work of any other of the four outlying Stations described in these reports. It is the representative of lands of similar grades in San Benito, Santa Clara, Monterey, San Luis Obispo, and I do not know how many more districts of the Coast Range. East of San José, on the Mount Hamilton road, beyond Hall Valley, one comes upon soil and climate much like that of the Station. Oak-covered foothills, hot in summer, often suffering from lack of rainfall, but responding to careful tillage, and certain to be occupied by home-seekers, no part of California more needs, nor will more amply reward, careful experiment. Last season the Foreman at the Station exhibited at the District Fair thirty varieties of wheat, fifteen varieties of barleys, four of spelts, nine of oats, and four of ryes. He also showed cotton, peas, buckwheat, grasses, and clovers. He had tables covered with grapes, peaches, and other fruits. Everything was grown on the upland without irrigation or expensive outfit. Any plain, common, every-day farmer can do as well.

It will be necessary to reservoir more water for the garden and nursery supply. The orchard, vineyard, grains, and many field and plot cultures ought to be grown without irrigation, but the land about the residence is a peculiarly dry soil, and needs more water to produce any satisfactory results. If oranges, lemons, walnuts, pecans, and chestnuts are to thrive at the Station, more water is needed, and the only way to obtain it is by boring the well deeper, constructing a cement reservoir, and supplementing the windmill with the horse-power.

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The nearness of the Station to the noted watering place and sanitarium of Paso Robles, and to the towns of San Miguel and Templeton, makes its general appearance a matter of more than ordinary importance. It has almost as many visitors as the South California Station, largely San Francisco business men and their families, and strangers from every part of the world, who visit the Paso Robles region. There is therefore no place where a rare and beautiful plant will be more quickly appreciated, or where the duties of the Experiment Station require more neatness and order than here, on the dry, but not barren, uplands west of the Salinas.

GRASSES, CLOVERS, SORGHUMS, AND SMALL CULTURES AT THE SOUTHERN COAST RANGE STATION.

From notes by R. D. CRUICKSHANK, Foreman.

The season of 1891 and that of 1892 were exceedingly dry. Rainfall was light in the Upper Salinas, and severe north winds came in spring, so that everything received a severe test.

Valuable Grasses.—The experience of three years is as follows: Among all the grasses tried none came near the Hungarian brome grass for prolonged verdure during the hot months. Shrader's brome grass and the Japanese wheat grass come next. One great objection to the Shrader's is the fondness of the gophers for its roots. Out of all of our grass plots they would continually persist in returning to destroy that particular plot. The Japanese wheat grass is of great promise here. We have now tried it for three years, and find it stools out excellently. It has the faculty of distributing its seeds over a range of 20 feet, thereby disseminating and perpetuating its species in a natural way. The Hungarian brome and Shrader's brome grasses also do this, the Shrader's in a more marked degree than the Hungarian. The rainfall has been light, and none fell from June 9th till October 27th. It is a long time for a plant to withstand the drought, and it takes something especially adapted to the task to survive at all.

The Rye Grasses.—The Italian and Australian grasses do well in the spring and early summer months. For those who are fortunate enough to have low, moist meadows, the Italian rye grass is a splendid producing and highly nutritive variety; but on elevated and parched plateaus, similar in situation to this Station, they will only last while the moisture does.

The Clovers.—Clovers, red and white, do well enough in early spring, and will ripen and cast their seed about, waiting the advent of the next fall rains.

Esparcet.—The sainfoin does very well here. It has stood for three years, and keeps the greenest of all our herbage throughout the dry weather. It does remarkably well on the west side of the Salinas, on the chalky-rock soil, where the long roots can penetrate. I have seen such roots 18 inches long after six months of growth. This plant is grown largely in France, and maintains many cattle on a very small area. I have sown it and transplanted it, and have given it all kinds of hard treatment, and it will still persist in living and keeping green. The jack-rabbits are so remarkably fond of it, that by sowing half an

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acre, and fencing it around, leaving a gate, it would be easy to trap hundreds of the animals.

Early Forage Plants—Kale.—Grass for grazing is going to be a serious question here; and unless the natural grass is augmented by some kind of green fodder under tillage, in such seasons as the one just past, cattle and sheep will have to succumb. Those having bottom lands can grow corn and sorghum and millet, also roots, such as carrots, mangolds, and artichokes, but on uplands these do not come to perfection. All things that can ripen by the 18th of August do well here. The Jersey kale seems to be an excellent thing to withstand the drought. It has done well every year here since we started the Station, and I have word from the coast that it does best of all the green feed there, which I can believe, as I have seen it in its native country 10 feet high.

Jersey kale should be sown in the month of October, and ready to be transplanted about March; it will then grow on through the spring and summer. By the time the dry weather comes it can be stripped of its leaves as required, and will still keep sending out more.

Citron Melons.—This year I find the citron melon gave a most abundant crop, whereas the other squashes and similar cucurbitaceæ did very little, owing to the light rainfall. I find the horses enjoy a few slices of the citron, and as these will keep through the winter, it seems to be a substitute where it is too dry to grow pumpkins.

Field Peas and Lentils.—Persons who raise hogs might plant peas in the month of November; they do well in any soil here, and are one of the best things to improve land. They would make a great deal of good feed for hogs, and would be garnered in time to summer fallow or to grow a crop of French millet on the same land that year.

Lentils do well and keep green long. They also improve the land.

English Beans.—Horse beans do well here, planted in the fall; they are not much understood here, but in England they are always fed with oats to horses, and as a mixture in the hot mash given to milch cows. They are boiled along with turnips, cut hay, chaff, etc., and are also used ground into meal. They are the richest of all legumes; they make a great increase in the quality and quantity of the milk. The adobe land of this county would grow them to perfection. I feel a great interest in the subject, because many farmers here who have been depending on wheat raising alone, are not advancing as rapidly as they might, and have had to pass through a very unprofitable season. I am happy to say that many of them are now planting out quite good orchards, and keeping poultry. The latter, if gone about intelligently, becomes a source of revenue, and in conjunction with the orchard, will eventually pay much better than the wheat fields.

Wheats for Hay.—In the matter of raising hay, among all the varieties of wheat we have grown for that purpose, I consider the Sonora as good as any. It is well known, and if planted very thickly it makes slender stems, but must be cut quite green. The other varieties which approach it are of similar type, such as the Chile. Some like the Australia, but as a rule it grows too rank, and the cattle reject the thickest part of the stems. The Sonora has the advantage in withstanding very hot weather, and it is not bearded. The Yellow Noe makes a fine fodder, having plenty of leaves. The same remark applies to Pringle's Best and Snowflake; but for regular crop the Sonora is hard to beat in this district.

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Barleys for Hay.—I think that barley makes a better hay than wheat. The Chevalier is a variety much appreciated by horses if cut pretty green, and as it is bearded it requires to be cut in that stage, otherwise it hurts the horses' mouths. If cut just right they will eat it all up. We grow an improved variety of Chevalier called "Hallett's Pedigree" Chevalier. The heads are finer and the stems are not as apt to fall down and lodge. This is a variety (the Chevalier) that is much inquired after, and commands about one fifth more in the market than ordinary barleys. It is used in brewing and largely exported for that purpose. It requires good, heavy land, such as adobe, to bring it to perfection.

Many prefer the beardless barleys. They give a fine yield of leafy hay, but should not be allowed to get too ripe before cutting. We grow one variety, called the Berkeley Hybrid, a two-rowed, beardless barley, that is a good thing here, but it will not make as much fodder as the common beardless variety. If I were restricted to one variety it would be the Bald barley.

Mixed Pastures.—We grow a lot of small forage plants, such as the snail clover and the bird-foot clover, etc., but they cannot be considered as other than a curiosity, and at best would only do as a mixture in making up a pasture.

I think that if a judicious mixture of the annual and perennial grasses could be made and tried on a larger scale than our limited area admits, and after a year or so cattle or horses turned in on it, the survival of the fittest would demonstrate the best varieties to plant in similar tracts.

In bygone days immense herds of cattle roamed about here. They gave place to sheep, and between them they have so denuded the pastures of the original growth of wild oats and bunch grass, more especially near the river, where they are wont to congregate, that the country looks more barren than the soil really is.

Sorghums.—We tried seven or eight kinds of sorghum this year, but the season was too dry, and they made only about one foot of growth.

Corn.—Corn was also a failure. It never has done any good at this Station. The hot winds come about the 20th of June and wilt it; before that it is full of promise. With the thermometer at 110° in the daytime and 51° at night, as we have here, the sooner one realizes that he is not in a corn country, the better. Frosts continue so late in spring as to render it unsafe to plant early, so there is not time enough for corn to establish itself before the moisture is all gone. I have tried lots of varieties, and given their cultivation the greatest care, and never got a decent head after three years' trial.

Buckwheat.—I have had good success every year by planting about the end of April. By far the best and earliest kind is the Japanese.

Garden Peas.—We planted sixteen varieties, and all did well. For a garden, the Little Gem and Bliss' American Wonder did best. Early Alaska came earliest. The way to plant peas here is to commence sowing about October and make three or four sowings for a succession. For field purposes, about November 1st suits, and they would then be off in time for some other crop.

Potatoes.—We tried seventeen varieties, but none of them came to any size. As a rule early potatoes do well enough in this district, but the same does not apply to late varieties, and nearly all the supply is brought from the coast, where they grow to great perfection.

All the early vegetables did well, and we had a good supply.

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This nearly exhausts the list of small cultures grown this year, and my concluding remark is that it has been by far the poorest season I have seen for years. The old residents say it has been the hardest year for seven years past.

Various Small Cultures in 1892.

Kind.	Sown.	Remarks.
Japanese wheat grass	Oct. 3	A perfect success.
Hungarian brome grass	Oct. 3	A perfect success.
Shrader's brome grass	Oct. 3	A perfect success.
Festuca elatior	Oct. 3	No value here.
Hedysarium coronarium	Oct. 3	Did fairly well.
Red clover	Oct. 3	All right till blooming, then died out.
Australian rye grass	Oct. 3	Made fine crop.
Medicago lupulina	Oct. 3	Good growth.
Paspalum dilatatum	Oct. 3	Poor growth.
Italian rye grass	Oct. 3	Light crop.
Trifolium repens	Oct. 3	Grew until flowering; died out.
Anthyllis vulneris	Oct. 4	Poor growth.
Alfalfa	Oct. 4	Grew remarkably well.
Sweet clover	Oct. 4	Made strong growth.
Sainfoin	Oct. 4	Has done well for three years.
Holcus lanatus	Oct. 4	Too dry.
Lotus tetragonolobus	Oct. 4	A fine growth.
Trifolium hybridum	Oct. 4	Poorly.
Agropyrum glaucum	Oct. 4	Without value.
Texas blue grass	Oct. 4	Seems valuable.
Millet grass	Oct. 4	Small crop.
Tall oat grass	Oct. 4	Grew fairly well.
Trifolium incarnatum	Oct. 7	Came up poorly, but did well.
Timothy grass	Oct. 7	Unsuitable.
French lentils	Oct. 7	Grew well every year.
Jute	Oct. 7	Came up, but perished; not adapted to the place.
Dyer's madder	Oct. 7	Grows well here.
Tagasate (*Cytisus proliferus*)	Oct. 7	Has done well for three years.
Persian insect powder plant	Oct. 7	Grew and bloomed a little.
Jersey kale	Oct. 7	Does well.

THE BROAD-TAILED SHEEP OF PERSIA.

By Charles H. Shinn.

One of the most promising of the recent acquisitions of the California Experiment Stations consists of a pair of the famous Broad-tailed sheep of the Orient. The history of the importation is interesting. Hon. Truxton Beale of California, a son of General Beale, was appointed United States Minister to Persia. All Californians know the famous Beale ranch, in the Tejon Pass, Kern County, one of the historic landmarks of the Pacific Coast, and especially attractive to breeders of fine sheep, cattle, and horses. It was natural that a member of the Beale family in public life should attempt to do something for the live-stock interests of his own State. He obtained for the United States Department of Agriculture fifteen of the best specimens of the pure-blood sheep of Asia, called the "Astrachan," though the latter name belongs to a variety. The proper name of the breed is the Bayazit Broad-tailed sheep of Kurdistan, Persia.

Minister Beale wrote to California, and placed the entire shipment in the hands of Mr. C. P. Bailey, of San José, a well-known importer and breeder of Angora goats. Mr. Bailey has several large ranches, one in

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Monterey County, California, another in Lander County, Nevada, a third in Socorro County, New Mexico, and a fourth in Harris County, Texas, and is an authority in the goat and sheep husbandry. He offered the Stations a pair of sheep, which were sent to Paso Robles, and placed in charge of the Foreman there, Mr. Cruickshank, who happened to be well acquainted with such sheep, having seen them in India.

Mr. Bailey made a very careful distribution of the sheep, and has kept track of them. He wrote me under date of October 31, 1892, expressing his satisfaction at the prospects, and saying:

"The more I see of these sheep the better I am satisfied that they are really quite an acquisition to California mutton-breeders. They are as 'tough' as mules. Not one has died since they left Persia, and seven out of eight of the ewes have had lambs since they started, all of which are alive and thriving. One lamb, sixty days old, weighed 50 pounds, live weight. One that was dropped here ten days ago weighed 13 pounds at one day old. I believe that by crossing these bucks onto the common Merino sheep of California, we will get as big lambs at three months old as ordinary Merino lambs are at six months old. I am arranging to try this cross-breeding in Nevada. I hope Mr. Cruickshank will try cross-breeding at Paso Robles. The lamb at Golden Gate Park is the finest and fattest I have seen yet."

The "Broad-tail" is the same breed of sheep that Gen. George Washington received from Asia a century ago, and that was used by the Custis family to help found the noted "Arlington Long Wools" of Virginia. It is surprising that the breed has not been used oftener as a cross. It is the sheep mentioned in the Bible, and is the only sheep illustrated on the ancient monuments of Media, Persia, and Assyria. It is said that there is no better mutton sheep in the world. The tail is chiefly a mass of fat, weighing from 10 to 40 pounds. Good sheep ready for the butcher ought to average 90 or 100 pounds, besides the fatty appendage. The largest are found in the Ararat provinces of Kurdistan, where sheep are often found dragging around wooden-wheeled carts, which support the tails. The more slender and beautiful Bayazit breed is smaller, but the fleece is finer. The soft skin of one variety of the Broad-tails is covered with a short, curly fleece, the "Astrachan wool," used by the Circassians. This variety, however, seems to be somewhat different from the Bayazit breed of the present importation. If the expectations of the importers are realized, some of the other breeds will doubtless be obtained for future crosses.

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D. SAN JOAQUIN VALLEY STATION.

One mile southeast of Tulare City, Tulare County.

By CHARLES H. SHINN.

GENERAL VIEW OF THE STATION WORK.

The work of the winter of 1891–92, and of the spring, summer, and autumn of 1892, at the very important Station of the San Joaquin Valley, has still more strongly emphasized the difficulties of the tract—difficulties deliberately accepted, because they arise from the nature of the chief problem chosen. There is no Station in the world, so far as I can learn, that is better situated for experiment with several grades of alkali soil, or that is in the midst of richer tracts of easily cultivated soils, free from alkali, and naturally adapted to profitable horticulture. The Station is near a thriving town, easily accessible during summer and winter over excellent roads. The ordinary expenses of carrying it on are fortunately very low, less in fact than at any of the three other outlying Stations. A larger part of the Station fund is thus directly available for the slow and expensive processes of experiment, observation, and reclamation. That such expenditure is amply justified by the high agricultural value of these lands when reclaimed, has been shown in former publications.

The conditions surrounding the Station Foreman and the workers of the Station staff are so peculiar that a general review seems desirable. Tulare County, like other California counties, contains within its limits a great range of soils, at various elevations, in the main valley, in the foothills, on high mountains, or in sheltered mountain valleys. Hence, the climate varies so greatly that every horticultural product that can be grown anywhere in California can probably find a congenial home somewhere in Tulare County. But if the best soil and the best climate in Tulare County had been selected, the Experiment Station would only be duplicating, with minor variations, the work being done elsewhere, and although the non-scientific mind might have received temporary gratification from the more rapid creation of a beautiful "show place," the permanent interests of the State at large, and of the surrounding community in particular, would have been sacrificed.

There are immense areas of land in California, in other States, in South America, India, and other places, that, while possessing all the elements of plant life, cannot be profitably utilized, owing to the presence of a superabundance of "alkali salts"—sulphate of soda, carbonate of soda, and common salt, together with salts of potash and the phosphate and nitrate of soda, in amounts which promise an almost indefinite duration of productiveness without fertilization on large areas now unavailable. The real harm is done when these lands, which properly belong for the present to scientific investigation, come into the hands of poor or ignorant persons, who inevitably find themselves

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unable to raise crops, and are entirely incapable of reclaiming the land. When all the alkali tracts of California are properly graded, and the spots that cannot at present be cultivated are separated from those that careful tillage will render available, it will be possible to concentrate much more labor and capital upon the reclamation of these more difficult portions. The scattered efforts of a few individual land-owners, working on lines recommended by the Experiment Station, have not yet excited general interest, but there are signs of growing attention to the subject.

It may be truthfully said that the Tulare Station was largely chosen in order to give the widest possible range to the study of the various problems connected with the subject of alkali spots. It has taken time for those who are actually engaged in the Station work to realize its comprehensiveness. My visits to the Tulare Station, as Inspector, have convinced me that we cannot expect a first-class orchard or garden there for many years to come. If we spend money and effort there wisely and steadily, we will ultimately accomplish that result, and have a "show place" to any extent that we desire. But our first line of work is to study the soil of the tract by such an extended series of analyses, in addition to those already made, that we shall know the amount and character of alkali at every place where a tree or vine is planted; also, wherever the rows, plots, or plants in various small cultures are set. We have to make these tests at different seasons, and in different years. Again, all the trees or crops of any sorts that we plant on alkali soils, or non-alkali soils, must be studied with direct reference to the whole mass of soil observations. In this way, and only in this way, can we come to know what plants thrive best, and under what conditions; and how the varieties differ in hardiness, fruitfulness, quality, and other matters. We have to ascertain, slowly but surely, how, by under-drainage, use of gypsum, and every other available agency, the surplus alkali about tree and vine can be removed or neutralized, and the exact amount required to be thus removed, in any given case, to change failure into success. We have to study and compare the fruits, cereals, and other products of alkali soils with those grown upon other soils. The subject is so broad, and includes so many lesser problems, that it will properly and necessarily require the labor of years to accomplish what has been thus briefly outlined. Meanwhile, decreased cost of reclamation, and increased population throughout the great valley, will unite with the advances of agricultural science to render the alkali soils highly valuable for human use.

All this can be illustrated to the reader by approaching the subject from another standpoint. Here are two peach trees of the same variety grown in the same row, 16 feet apart. The soil looks alike at both points. Pruning and culture have been as nearly as possible alike. But one tree, upon beginning to bear, loses its leaves and fruit; the peaches that reach maturity are coarse, thick skinned, tough and tasteless. The other tree produces excellent fruit. Analysis determines that there is a difference in the amount of alkali under the two trees; examination of the roots shows that the tree that failed has suffered from that agent. It is plain that we must subtract or neutralize a certain definite amount to give the tree a chance. But if the two trees, under the above conditions, happen to be of different varieties, or if one is a peach and the other a plum, or if they are on different stocks, then the subject

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becomes more complex; we shall have to institute a series of other experiments before we know how much of the credit for the result belongs to the alkali, and how much to the variety, the species, the stock, or any other circumstance. The individual plant or tree is merely the pawn in the game, and we must always be ready to sacrifice it for the sake of the investigation. This is not so much true of the Stations where the soil problem is less immediately pressing, but at Tulare it is a self-evident fact. Garden, orchard, vineyard, small cultures, are all subordinate to the study of the soil under all conditions and at all times. It must be remembered, too, that the governments of England, Russia, and other countries are spending large sums upon precisely this line of investigation, and that the small beginnings of the Tulare Station, which is only one of the four outlying Stations, are being watched by workers in Russia, India, Australia, Africa, and many other regions where these surplus salts abound. Viewed from this standpoint, the irregular orchard of the Tulare Station presents one of the most interesting of the agricultural experiments of the present time.

A portion of the report of this Station will be found in the special report on figs; also in that upon the improvements at the various Stations, and in notes upon alkali soil and its treatment. This separate report deals with the orchard and other cultures (except the vineyard), and with some of the general problems of the district.

THE ORCHARD.

The general appearance of the orchard in the autumn of 1892 is characteristic of the spottiness of the tract. It will be impossible to have an even, well-grown orchard on such land until the worst spots of alkali are still further reclaimed. In some respects the orchard, however, is encouraging; it is far better than any orchard I have examined on similar soil, and portions of it begin to yield fair fruit. The planting of the winter of 1891–92 was small, because the stocks desired could not be obtained, and we had to wait and grow them ourselves. In some of the worst spots it seems useless to plant again until the percentage of "black" alkali is materially reduced.

Apricots.—These made a fair growth, and some will bear next year. Half a dozen on heavy alkali soil have died, whether on apricot, plum, or peach stock. Those on light alkali made small growth, but seem well rooted. Those nearest the avenue, on soil comparatively free from alkali, would pass muster as trees of medium quality in commercial orchards. More than this cannot be said, and the strain will come upon even the best of the apricots when they begin to bear. The Royal is the best grower. Luizet and Breda fell within the alkali spots.

Peaches.—The best trees are really very satisfactory, and if the whole peach orchard were as good as the best half of it is, the soil would need little more treatment. The worst patch of black alkali affected a number of trees in this their first bearing year. Five trees appeared to lack the constitution to carry a fruit crop on this soil; they dried up when the peaches were the size of walnuts, and the tops had to be cut back. None of the fruit in the strong alkali was of even fair quality. The peach trees in lighter alkali showed a tendency to overbear beyond the normal rate of young trees, but the quality was fair to medium. Peaches treated with gypsum on this portion of the tract looked better. The rate

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was 500 pounds to the acre, but no results could be perceived from the same rate of application to the strongest black alkali of the peach orchard. It will take another year to report much upon separate varieties. The clings, as a class, stand somewhat better than the free-stones; the California seedlings, too, show some points of advantage, but it is too early to select the hardier sorts. The soil where a dozen trees of the orchard are set, will have to be treated further before it is worth while to permanently plant there again.

Plums.—This fruit does best on sandy soil. The Japanese varieties are distinctly a failure on alkali land, as foreshadowed in the last report. They grow very slowly, and the fruit is harsh, dry, and tasteless. The usual flavor and juiciness of these plums are entirely lacking. The European plums continue to stand much better, and the American plums also warrant further test. Golden Beauty is of its usual flavor, and fair size on alkali; McLaughlin is not. Prunus Simoni continues to grow well in alkali surrounded by several European trees that suffer. Among the very bad failures are the German Prune, the Royal Hâtive, and Ickworth's Imperatrice. Fifteen trees in all are dead from alkali, and about twenty more look badly. The plums get a larger slice of both patches of alkali than do the peaches. The Cherry plum suffers from alkali; the Mariana appears much better, and deserves commendation as a stock. In fact, the Mariana seems one of the hardiest of all. St. Lawrence and Columbia, in sandy soil, have made large growth and have borne good fruit. Among other trees that have borne this summer, are Belle de Septembre, Ontario, and Coe's Golden Drop.

Nectarines.—Record somewhat improved; but, for some reason, the nectarine in every variety is more susceptible to alkali than either peach or apricot. Hardwicke and Newington are fairly good trees. Eleven out of twenty-five trees in this tract died, owing to alkali; and when reset, after gypsum treatment, nearly half again yielded to the enemy.

Almonds.—It is instructive to observe the ruggedness of the Bidwell Seedling, and of several hard-shell varieties. No other trees in the orchard showed greater differences in size than the almonds did. Some, on alkali, still appear to be yearlings, while others seem five-year-olds. Though the district is so frosty, there is a chance that some varieties may bear, owing to the fact that the spring frosts are not as late as in some warmer districts. Bidwell Seedling is already bearing a little.

Apples.—Satisfactory growth, considering the lightness of the soil. The effect of alkali is more evident than last year. Some trees are dead, others nearly so. Quite a number show blight at the ends of the young growth, and the roots show the biting effects of alkali. Ten per cent of the apple orchard suffers more or less from this cause. It is evident that little or no difference in hardiness has been shown as yet.

Pears.—The test in relation to alkali appears to give more distinct results with the pear than with any other species of fruit, and the results of 1891 are still further developed. The following table, representing the condition of a part of the pear orchard, will enable the reader to see at a glance the enormous effects of alkali of differing strengths upon trees planted at the same time (in 1880–89). It is impossible to determine, without a long series of future tests, whether some varieties are less susceptible than others, but a few points can be approximately ascertained:

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Synopsis of Pears.

Name.	Height.	Soil.	Condition.
Vicar of Winkfield	10 feet	Little alkali	Healthy tree.
Dearborn Seedling	8 feet	Little alkali	Healthy tree.
Beurré Clairgeau	10 feet	Little alkali	Bearing tree; good growth.
Josephine de Malines	3 feet	Strong alkali	Very poor.
Jeane de Witte	4 feet	Medium alkali	Fairly healthy.
Keiffer	9 to 12 feet	Medium alkali	Excellent.
Le Conte	9 to 12 feet	Medium alkali	Excellent.
Bartlett	8 feet	Medium alkali	Leaves burn; scant growth.
Doyenne Boussock	2½ feet	Strong alkali	Just alive; few leaves.
Tyson	3½ feet	Slightly less alkali	Leaves healthy.
Brockwell Park	3 feet	Strong alkali	Dead.
Urbaniste	2 feet	Strong alkali	Nearly dead.
Beurré Diel	2 feet	Strong alkali	Nearly dead.
Beurré Bosc	4 feet	Strong alkali	Improving a little.
Emile d'Heyste	20 inches	Strong alkali	Single stem; nearly dead.
Dr. Reeder	6 feet	Medium alkali	Fairly healthy.
Howell	7 feet	Medium alkali	Healthy.
Bloodgood	2 feet	Strong alkali	Dead.
Beurré Superfin	2 feet	Strong alkali	Nearly gone.
Gray Doyenne	2 feet	Strong alkali	Nearly gone.
Flemish Beauty	5 feet	Strong alkali	Fair health.
Onondaga	6 feet	Strong alkali	Very healthy; bearing fruit.
Jaminette	6 feet	Medium alkali	Fairly healthy.
Beurré Hardy	8 feet	Medium alkali	Fairly healthy.
Columbia	6 feet	Strong alkali	Good.
Beurré Gris	5 feet	Strong alkali	Yellow leaves in summer.
Duchess d'Angouleme	5 feet	Medium alkali	L'ves worse than preceding.
Doyenne d'Alençon	5 feet	Medium alkali	Healthy.
Barry	6 feet	Light alkali	Healthy.
Sheldon	6 feet	Some alkali	Medium.
Van Mons Leon le Clerc	4 feet	Medium alkali	Healthy.
Beurré d'Amalis	12 feet	Light alkali	Largest tree in orchard.
Pound	6 feet	Light alkali	Fair.
Glout Morceau	5 feet	Light alkali	Healthy.
Easter Beurré	6 feet	Light alkali	Leaves small.
Seckel	7 feet	Strong alkali	Very fair.
B. S. Fox	3 feet	Strong alkali	Dead.

The foregoing table will serve to show the condition of the most interesting part of the pear orchard—that which crosses an alkali tract which has already received gypsum at the rate of 1,000 pounds to the acre. The following kinds have been killed during the past two years: Gray Doyenne, Beurré Superfin, Bloodgood, Winter Nelis, Emile d'Heyste, Urbaniste, Brockwell Park, Doyenne Boussock, Anne Ogereau, Seckel, and B. S. Fox. There are fourteen more trees that are injured by the alkali. The trees standing where the soil is comparatively free from alkali need little comment in this connection. Some twenty varieties come in this category. Idaho, in alkali, does poorly; Kennedy, in light alkali, is 12 feet or more in height, and many others are quite as good.

The character of the fruit on some trees in strong alkali is worth notice. A Louise Bonne de Jersey in such a situation showed yellow leaves in September, when most of the pear orchard was still green. The one fruit, gathered September 25th, was small for the variety, pale yellow, without the usual red cheek; was rough and knotty outside, and the flesh was tough, dry, and of a peculiar flavor. It was unmistakably a Louise Bonne, but it was a very poor one. The fruit of Onondaga, or Swan's Orange, gathered the same day, was unusually elongated for that variety, and about one half the normal size. The flavor was fair. but the flesh was exceedingly gritty. This tree, like the Louise Bonne de Jersey, stands in strong alkali. The chemical changes, if any, pro-

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duced in such fruit by the soil must be determined from the next year's crop, but it seems probable that the hardiness of many pear trees (in reference to alkali soils) is greater than the capacity of the fruit to develop properly under such adverse circumstances. In other words, the limit of successful pear culture in alkali soil is often fixed as accurately by the quality of the fruit as by the growth of the tree, and both must be taken into consideration.

The Seckel pear is a curious instance of the complexity of the elements involved. The tree noted in the table as growing strongly and well in strong alkali might be thought to settle the place of that variety as more than usually hardy. But it happens that another tree of Seckel was planted, a year later, in lighter alkali, and died there, showing decided marks of corrosion at the surface of the ground, and on the larger roots. The stock was the same as in the other case. Either the winter in which the second tree was planted was very dry, and the following summer was very hot, or the tree itself was badly grown, perhaps forced by too much irrigation, planted late, with shortened roots, and so was immediately attacked by the enemy.

Olives.—The healthy growth of the olive in quite strong alkali soil has been noted in my previous report. There is little to add, except that the frost seems to attack trees upon alkali more than the same varieties upon non-alkali soils. We shall probably have to acknowledge that Nevadillo blanco is more tender than previously reported, a four-year-old tree having been killed by the extraordinary cold of December 25, 1891, which gave the fig avenue so hard a test. Pendulina, Rubra, and a few others begin to show a little fruit.

Other Fruit Trees.—The figs are so fully reported elsewhere that it is only necessary to say that the avenue is recovering after its injuries from frost, and many varieties are beginning to bear. The pomegranates are loaded with fruit this year, and are to be tested on the strongest alkali. The mulberries continue to thrive, and illustrate their value as shade trees, and as yielding fruit for poultry and hogs, in such regions as the San Joaquin Valley. The oranges are in better condition to stand the winter, but entire success with standard oranges is problematical at this point in the valley. The true orange belt lies along the Sierra from Porterville north and south for miles. The Japanese oranges do much better. Both walnuts and chestnuts suffer from the hot sun. The Kai apple (*Aberia Kaffra*) was winter-killed December 25, 1891. The Camphor is making a beautiful tree.

Ornamentals.—The Station Foreman is beginning to improve the appearance of the ornamental grounds, though much remains to be done. He has a few vines and flowering plants and a little grass sown. The line of hardy shrubs unknown to the region will be increased; also such hardy vines as stand hot summers, to cover the Station buildings.

THE CEREALS.

In the cultivation of wheat and other cereals without irrigation on land with considerable alkali, the soil was plowed twice, and the grain sowed before the first rains, in drills. No fertilizer was used. The season was very dry, and all the cereals suffered.

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The following table, sent by the Foreman, Mr. Forrer, shows results:

WHEAT.

Variety.	Length of Drill.	Yield, in Pounds.	Comparative Yield (Drill of 45 Feet).	Average Yield per Acre—Pounds.
Archer's Prolific	145 feet.	20.00	6.20	6,051
Volo	90 feet.	8.50	4.25	4,148
Whittington	145 feet.	13.50	4.18	4,079
Arizona Indian	90 feet.	4.50	2.25	2,196
Petali	45 feet.	2.50	2.50	2,440
Missoyen	90 feet.	5.00	2.50	2,440
Blue Glass	45 feet.	2.75	2.75	2,684
Diamond, or Polish	45 feet.	1.50	1.50	1,464
Royal Australian	145 feet.	20.00	6.20	6,051
Oregon Club	145 feet.	18.50	5.74	5,602
Rust-proof Indian	145 feet.	4.00	1.24	1,210
Nonpareil	45 feet.	8.00	8.00	7,808
Taganrog	45 feet.	1.50	1.50	1,464
Nicaragua	45 feet.	2.50	2.50	2,440
Harris, from Jasper	72 feet.	11.00	6.87	6,705
California Spring	72 feet.	18.00	11.25	10,980
Fern, or April	45 feet.	2.50	2.50	2,440
Improved Circassian	45 feet.	4.00	4.00	3,904
Red-Bearded	45 feet.	3.00	3.00	2,928
Forelle	45 feet.	1.75	1.75	1,708
Clawson	60 feet.	15.25	10.17	9,926
Hungarian (Burke)	45 feet.	2.00	2.00	1,952
Victoria	45 feet.	1.75	1.75	1,708
Pringle's Best	145 feet.	13.50	4.18	4,080
Genoese	45 feet.	3.50	3.50	3,416
Ghurka, or Odessa	45 feet.	1.75	1.75	1,708
Red Club, or Hedgehog	45 feet.	1.50	1.50	1,464
Chile	145 feet.	10.50	3.25	3,172
Indian Three Months	145 feet.	13.50	4.18	4,080
Indian Winter	145 feet.	11.50	3.56	3,474
Champlain	45 feet.	2.00	2.00	1,952
Snowflake	145 feet.	10.00	3.10	3,025
Thuringian	145 feet.	10.75	3.32	3,240
Tauzelle	45 feet.	3.50	3.50	3,416
Michigan Mixed	145 feet.	10.50	3.25	3,172
White Banate	45 feet.	1.75	1.75	1,708
Pringle's Defiance	145 feet.	12.00	3.72	3,630
Yellow Noe	145 feet.	11.00	3.41	3,328
Frankenstein	45 feet.	2.75	2.75	2,684
Hungarian (Brenner)	45 feet.	2.00	2.00	1,950
Russian Red-Bearded	45 feet.	2.25	2.25	2,196
Black Centennial	90 feet.	3.00	1.50	1,464
Egyptian	45 feet.	2.00	2.00	1,952
Defiance	45 feet.	5.00	5.00	4,880
Greek Atlanti	45 feet.	2.00	2.00	1,952
Palestine	90 feet.	3.50	1.75	1,708

RYES.

Variety.	Length of Drill.	Yield, in Pounds.	Comparative Yield (Drill of 45 Feet).	Average Yield per Acre—Pounds.
Swedish Sand	90 feet.	5.25	2.62	2,557
Perennial Saxon	90 feet.	5.25	2.62	2,557
Spanish	90 feet.	5.00	2.50	2,440
St. John's Day	90 feet.	4.25	2.12	2,069
Excelsior Winter	90 feet.	6.25	3.12	3,045

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BARLEYS.

Variety.	Length of Drill.	Yield, in Pounds.	Average Yield per Acre—Pounds.
Black, six-rowed	145 feet.	13.5	4,080
Manchurian	145 feet.	23.0	6,959
Italian	145 feet.	18.5	5,602
Himalaya	145 feet.	26.0	7,875
Nepaul	145 feet.	21.0	6,353
Kalina	145 feet.	15.5	4,694
Scotch	145 feet.	12.5	3,811
Large Naked	145 feet.	17.0	5,143
Bluish	145 feet.	13.5	4,080
Earliest Black, two-rowed	145 feet.	17.0	5,143
Chevalier	145 feet.	16.0	4,841
Hallett's Pedigree of Chevalier	145 feet.	15.5	4,694
Carter's Prolific	145 feet.	15.5	4,694
Imperial	145 feet.	12.5	3,811
Rice, or Sprat barley	145 feet.	6.5	1,961
Brenner, six-rowed	72 feet.	5.5	3,347

Wherever the alkali was strongest the yield of grain was diminished, as noted in previous reports. The hot, dry summer, after a light rainfall, diminished the yield, even on the best soils. The Foreman reports that Black Centennial seems identical with a wheat being distributed under the name of "Mount Whitney," and widely advertised as a superior variety. The Centennial does not appear to have any especial merit in this district.

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E. SOUTH CALIFORNIA STATION.

In the Chino Valley, between Pomona and Chino.

By CHARLES H. SHINN.

This Station, which is intended to represent a large number of special cultures, is that of Southern California, situated upon 30 acres of land given to the University by Mr. Richard Gird, owner of the famous Chino Ranch. The Station is easily accessible from several growing railroad towns, and lies in the heart of the valley, close to the boundary line between San Bernardino and Los Angeles Counties. The main Station tract is 3 miles southeast of Pomona, and a lesser tract of 10 acres of moist land is 2 miles south of the Station. This smaller tract has been broken at considerable expense, and a portion is planted to alfalfa. After proper drainage, this moist, dark loam land will form one of the best parts of the Station possessions, and will be particularly well adapted to forage plants, walnuts, small fruits, and many important cultures.

IMPROVEMENTS.

During 1891 a circular reservoir of cement was constructed on the highest point of the tract. It is 60 feet in diameter, 5 feet deep, contains 100,000 gallons, and is built in the best manner of stone, brick, and cement. The Foreman, Mr. K. McLennan, writes that it has proved essential to the success of the Station, and adds that "the volume of the water from the main line was insufficient for irrigation." "The reservoir," he says, "is 200 feet west of the house, and 400 feet from the northeast corner of the tract, where the end of the main is. This made it necessary to lay more pipe, extending the main line 400 feet in order to get the water into the reservoir." The sloping bank of earth about it is to be covered with vines, grass, and flowers, and a collection of rare species of water-plants, presented by Mr. Josiah Stanford, of Warm Springs, Alameda County, has been placed upon floats and supports, after the manner adopted by Mr. Stanford himself. The reservoir is one of the most conspicuous objects at the Station, and its beautifying was essential; in fact, I may say that no Station will better repay, or more distinctly requires a reasonable amount of ornamentation, than the South California. Mr. McLennan writes: "The tract is bounded by three streets. The north street is 33 feet wide, the east street 66 feet, and the west street is 50 feet, all of which we have partly graded, and have planted to shade trees as follows: On the north, Norway maples and Huntingdon elms; on the east, lindens and European sycamores; and on the west, elms, sycamores, and lindens. All of these have done remarkably well, excepting the lindens, which seem to suffer from the dry atmosphere and intense heat of the summer months, and will probably do better on the damp land of the 10-acre tract." Walnut and olive groves are directly across the main avenue that passes the Station,

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and in a few years the district will be closely settled and superbly improved.

Some hedges of dwarf fruits, such as the twenty or more varieties of the Japanese quince, or *Citrus trifoliata*, grafted to forty or fifty varieties of small oranges, are to be established at this Station, to add beauty as well as usefulness. Some of the strongest-growing species of *Vitis* sent to the Station among the new grapes of this season (1892–93) have been planted in trellis form.

The barn, stable, wagon-shed, and workshop, which were under one roof, have been extended so as to nearly double the ground space, and are now a credit to the Station, whereas they were before too small, which compelled us to leave the greater part of the tools outdoors, and to buy our hay supply in small purchases at high prices, for lack of storage. The water supply of the house and stable has been completed, by using two small tanks, one in the ground, and one at the top of the house, and a light pump. The water in the reservoir is totally unfit for domestic use. Several necessary repairs and alterations have been made in the main Station building during the present year. Water pipes and faucets are set at intervals about the grounds near the house, so that rare and valuable semi-tropic plants can be properly cared for, and the soil, which is very loose and light in the corner of the tract, can be covered in places with new trailers and creepers.

In order to increase the home supply of the Station itself, a small but effective propagating house was built during 1892, and a portion of the tract near the reservoir selected for a nursery, where stock can be grown, and new fruits, not yet obtainable in tree form, can be budded or grafted, thus reducing expenses.

The fence about the 30 acres has been strengthened by the addition of two 6-inch boards to the wire netting, one at the bottom with a furrow thrown against it to keep rabbits from burrowing underneath; the other at the top to keep stray cattle from pushing the netting down to get at the orchard and green crops within.

THE ORCHARD.

The entire orchard looks well and the trees have made a good growth. The percentage of loss has been less than at any other Station. The orchard, including the plantings of 1892–93, contains about one thousand trees, in some five hundred varieties. The collection of walnuts, prunes, figs, apricots, peaches, olives, and other fruits particularly well adapted to the district, has been greatly increased.

Olives.—The twenty-one varieties planted in 1891–92 made a good, strong, and healthy growth. The new varieties sent this winter appear to be doing well. The olive is well adapted to Chino Valley, and olive growing is becoming one of its leading industries. The trees received two irrigations, one in July, the other in August; cultivation did the rest.

Citrus Fruits.—Oranges and lemons have done well, although the location, which is in the valley some distance from the hills, is not considered the best for citrus fruits. The growth of the trees has been very vigorous, although they passed through the severe freeze of December, 1891, without any protection whatever.

Half the oranges are budded on Florida sour stock. This was done so as to study the relative values of the two stocks for standards and gen-

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eral orchard use. Mr. McLennan, a careful observer, writes as follows: "Although there is not much marked difference between their growths, I am inclined to think that the sweet stock has the advantage, though it is a year younger than those budded on the sour stock." He also says: "Four sour and four sweet seedlings received from Riverside in 1891 were the same in size and age. They are planted side by side in the same row, and have been treated exactly alike. Between these there is a marked difference in growth. The sweet stocks are much larger, more vigorous, and have a healthier appearance. They also stood the frost better than the sour stocks did. It is not reasonable to believe that orange stock, or any other stock, grown in the swamps of Florida, would do equally as well as the home-grown sweet seedlings from the arid lands of Southern California. Perhaps with an abundance of water, the sour may outgrow the sweet stock, but the point here is to get a stock that will do well with the least amount of water."

The oranges and lemons received three irrigations, not too late in the season. The citrus trees planted in the winter of 1892–93 nearly completed the orange orchard, but left a little space for new oranges to be received in the future.

Cherries.—Among the new sorts sent to the Station are several California seedlings—the Chapman, Advance, and Thompson. The trees made a fair growth. They received two irrigations. A full assortment of cherries will be planted here in the course of time, for stocks, and for distribution of buds to the higher valleys of Southern California, but the cherry is not likely to be generally planted in the Chino Valley, where the olive, prune, and apricot do better.

Almonds.—The almond has done so well, making an enormous growth, that all the new varieties obtainable in California have been sent to the Station. There are only a few almonds planted in Chino Valley as yet, but Mr. McLennan reports that much interest is felt by the fruit growers, in the Station collection. The yearling almond trees planted in the spring of 1892 received two irrigations. They looked like three-year-olds before the leaves fell in the early winter.

Plums and Prunes.—Like the almonds, the plums and prunes made a good growth—in some cases as much as 8 or 10 feet the first season. Among the prunes planted are Elmore, Golden, d'Ente de Puymirol, Ruby, Diamond, Mont Barbat d'Ente, and Lot d'Ente.

Pears.—There has been less growth in the pear orchard than anywhere else among the fruit trees. The soil is light and not well adapted to pear culture. Pears will do better in the ten-acre plot when it is fit for permanent planting. For stocks and exhibition purposes, however, it will be advisable to keep a small pear orchard on the main Station tract. Only a few varieties were added last season. The strong growers are preferable on the light soil.

Apples.—The apple trees grew better than the pears, and fair success can be expected. Among the new varieties sent here were many seedlings from the Southern States, adapted to a warmer climate; also the best of the new California seedlings, in the hope of finding some better keepers, and apples of higher flavor.

Figs.—The trees sent to the Station were small, and some varieties suffered from frost, but started again and made a fair growth. The fig is undoubtedly a strong factor in the future horticultural growth of the

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region, and the collection already large has been increased. (See special report upon figs at the outlying Stations.)

Peaches.—Mr. McLennan writes that the "peach trees upon their own roots made a very large growth, some of their trunks now measuring 3 inches in diameter. Those on the almond are next in growth, but those on the Myrobalan are more dwarf and show less vigor in their growth." This, of course, is what was expected. On the moister tract, plum stock, not only Myrobalan, but other species, will be tested hereafter. Peaches lately sent to the Station, all on peach stock, include about fifty new sorts, many of them not before planted in California, and local seedlings of promise.

Apricots.—Like the prunes, the trees made a marvelous growth, and are now 20 feet high, with broad, even heads. Of new varieties, the Gooley, Flickinger, Esperen, Boulbon, Early Musk, Peach of Nancy, Kell's Peach, and several others not before distributed have been planted here.

Walnuts.—The plantation now contains almost all the varieties known and several distinct species. Among them are the Bijou, or Large Fruited, Chaberte, Santa Barbara, Common English, Franquette, Mayette, Serotina, Vourey, Præparturiens, or Dwarf Prolific, in three sorts, Weeping, Barthere, Vilmorin, Meylan, Mesange, Mammoth or Jauge, Alpine or Wonder of the Alps, Parisienne, and Juglans racemosa. Mr. Felix Gillet, of Nevada City, importer and propagator of many of the above varieties of Juglans regia, wrote to me under date of December 20, 1892: "All my grafted walnuts are grafted from the original, or from grafted trees grafted from the original. The large-fruited Præparturiens is of recent introduction, and has not yet borne with me." The Mammoth or Jauge walnut is said to have shells so large that cases for a pair of gloves or a handkerchief are made out of a pair. The Alpine is a new and rare walnut from the French Alps, quality extra. The Weeping walnut tree droops its branches, like a weeping willow. The Serotina buds so late in the season as to escape many frosts. The Mesange is the true paper-shell walnut—perhaps the thinnest shell of any variety.

Other Fruits.—Mr. Gillet writes as follows of some new and rare varieties of fruit sent to this Station: "The St. Ascycles peach I received from the south of France. It ripens just between Briggs' May and Hale's Early; it is a perfect free-stone.

"Directeur Alphonse is a magnificent pear, and a splendid keeper. I am just introducing it for market uses; have but a few trees. The Blanquette is a choice little pear, splendid for canning. One kind of Blanquette ripens two weeks before the other. I did not know that there were two kinds, but as it fortunately happened, I grafted both into a large tree when I received scions from France, and got both kinds.

"The little White Magdalen fig is a beauty, and the earliest fig known. First crop ripens in June.

"Jaune Hâtive is the earliest plum I know of. Monsieur Rouge is a very old variety of plum; it was named Monsieur after the brother of Louis XIV, of France, over two hundred years ago. I never eat a Coe's Golden Drop, or a Pond's Seedling, or any such plum, but I like to eat a Monsieur Rouge or a Jefferson.

"I have six varieties of the Prune d'Ente, but two of them, the Mont Barbat and the Lot, are much like the French prune, while the others differ more decidedly."

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General Orchard Notes.—Trees of the same varieties, received from different sources, are carefully labeled and compared. We now have French prunes from several sources, and shall soon know how many types exist (as suggested in Mr. Gillet's letter). We have the Moorpark and Peach apricots from several distinct lines of stock, each claimed to be superior to the others. Nearly all of the standard market fruits can be had in what gardeners would term "strains," some one of which are doubtless better worth propagation.

The pomegranates did well at the Station, and several new varieties have been sent there.

Japanese persimmons were a total failure for reasons not clearly understood; new stocks, seedlings of our own, grafted, will be tried hereafter.

Guavas, two varieties, were winter-killed by the frosts of 1891. Well-grown specimens have not yet been obtained for replanting. The frost was then so exceptional that there is no reason to fear the loss of well-established plants.

THE VINEYARD.

More than a hundred varieties of grapes were planted in 1891, and this season a large part of the collection of the other Stations have been duplicated here, besides the new Persian grapes and a collection of different species of *Vitis*. The vineyard has made a satisfactory start. Vines in nursery for future planting look well.

DATE PALMS.

A report from the Foreman, December 20th, says that the "Date palms have come so far through the winter's freeze in good shape, with the exception of one small one (Amreezeh), which died. The Fard date palm, received from the Department of Agriculture, at Washington, also died. Although the heart of it was yet green when received, it had no roots." (See special report upon African date palms.)

PERENNIAL COTTON.

A remarkable perennial cotton plant from Peru made a most excellent stand, and an average growth of from 4 to 5 feet in height. It commenced to bloom in November, which was too late to make cotton. It is also very sensitive to cold, and the frost seems to kill the top off. If it can be carried through so as to test it another year, it may prove an acquisition in the warmer districts, as perhaps it will bloom earlier another season. The Foreman is giving it especial attention.

SUGAR CANE.

Five varieties were sent from Louisiana to the Station. The striped variety made an excellent stand. The others, so the Foreman reports, arrived in poor condition and failed to grow. The collection will be duplicated and other varieties obtained.

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CASSAVA.

This famous food-plant, sent from Florida, thrives at the Station and is increasing rapidly. A number of other cultures are becoming established and will furnish material for future reports.

GENERAL VIEW.

The Station of Southern California has made a fair beginning, but much must be done there to develop a stronger local interest in its progress and welfare. Chino Valley lies in the midst of most interesting and extensive horticultural districts—all the settlements of the Riverside and San Bernardino Valleys east and south, all the San Gabriel Valley settlements west, San Diego, the Los Angeles coast, Ventura, and Santa Barbara—all more or less interested in the work of the Station. The field is so large that it will take years of the most conscientious effort to cover the most important portions.

The Station should not make ornamental and temporary results paramount, but it need not neglect the beauty of well-kept grounds, hedges, and lawn, for it will soon be in the midst of "farm-gardens" of progressive and wealthy people, such as built up Pasadena, Riverside, and Redlands. The larger usefulness of such extended series of horticultural experiments as shall benefit the southern counties of the State, and all similar districts, is, of course, the primary aim of the Station. Its field of work differs from that of the other outlying Stations, chiefly in the wider range of its occupations. The date, orange, olive, and fig, the apple, cherry, pear—fruit for every season—forage plants, and small cultures for every climate, belong to the group to be tested here.

All the semi-tropical trees and plants, besides many that are usually termed tropical, can be grown with proper care at the Station. Besides encouraging the industries already established, such as the production of citrus fruits, the Station has a large work to do in the introduction of new species and new varieties of species already naturalized.

When the experimental orchards are established and in bearing they will be of much service in determining nomenclature and in maintaining in cultivation valuable varieties that would otherwise be lost. The purely commercial horticulturist is constantly losing sight of very valuable varieties of fruit that he tries to recover a few years or decades later, often unsuccessfully were it not for these experimental orchards that contain complete collections for study and comparison.

There is no doubt of the permanent value of the South California Station, now fairly beginning its useful work.

SUGAR-BEET CULTURE.

(Mr. Richard Gird, the Patron of the South California Experiment Station, has kindly written the following interesting paper, giving the results of his experience upon Chino Ranch):

Friable soils that will raise other good crops, such as corn, alfalfa, and even grain, will, with an amount of moisture equal to a rainfall of from

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10 to 11 inches each year, and with proper cultivation, raise good sugar-beets.

As to the kind of seed best adapted, I will say that, after experimenting with something like a dozen different varieties, the variety called by us "No. 5 of Florimond Desprèz," which is a long beet originated by selection, and cultivation of the soil to one meter in depth, is the best kind for the drier loamy soils where the tap root will penetrate very deep to bring up the moisture for the sustenance of the plant. For the next lower grade of soils I have found that the variety of beet furnished by LeMaire, and marked "L. R.," is a very satisfactory beet, as also the Klein Wanzlebener, of which latter there are many varieties, each given a different name, such as the Vilmorin Ameliorèe Improved Klein Wanzlebener, the Desprèz Klein Wanzlebener, and the Original Klein Wanzlebener, etc., all of which are very much alike and are good varieties, both for tonnage and sugar, on moderately deep soils with a medium amount of moisture.

On the lower or moist lands, such as will grow alfalfa or corn, I have grown the Vilmorin Ameliorèe, so far not with marked success, as while the purity and sugar is very high the tonnage has been hardly up to the average. This year, I shall try planting rather late the Improved Klein Wanzlebener in conjunction with the Vilmorin Ameliorèe.

The first beets cultivated by me on the Chino Ranch in an experimental way about five years ago, were planted in small patches a rod square at each planting, during the different times of the year and on different parts of the ranch, with the rows 16 inches apart, and the beets from 6 to 8 inches apart in the row; this I soon found was too close for our soils where no rains fell for the summer months, during the growth of the beet. When I began to plant for regular field cultivation, I planted the rows 17 inches apart, with the beets from 5 to 8 inches apart in the row. The first season demonstrated that this was also too close, and the second year of field culture I planted the rows 20 inches apart, with the beets from 6 to 10 inches apart in the rows; this I find, while the rows are far enough apart, is still too close in the row for the larger varieties in the medium moist lands, where the beets should not be closer than 10 inches apart. This year I expect to plant the rows 20 inches apart, with, on the uplands, beets 10 to 12 inches apart, on the semi-moist lands, 8 to 10 inches, and on the moist lands, 8 inches apart, in the rows.

I drill in the seed with a machine made by myself, and which answers the purpose admirably, and plant from 13 to 15 pounds of seed to the acre. If the seed comes up well, this should make a thick continuous row of beets, which are thinned out by hand (thinning is the main expense in raising beets) to the distance apart as mentioned above. All that is necessary after thinning is to keep down the weeds, and to keep the land stirred until the leaves have become so large that working among the beets has become impracticable. I use a cultivator that for the first cultivations operates as a hoe, cutting out all the weeds and just missing the rows; this cultivator is worked by one man and a horse, and cultivates four rows at a time. The horse and man should cultivate in this manner about ten acres a day. For the last cultivation I change the teeth of the cultivator to a stirring tooth, which leaves the land loose, and is the last work done until harvest.

The old way of harvesting is to run the beet plow, that has a narrow

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flange, alongside the row to loosen the beet, then pull out the beet by hand and cut off the top with a knife; this is all very expensive and slow. This year I have tried, with fair success, a puller invented by H. B. Martin, which pulls all the beets, little and big alike, and leaves them on the top of the ground, after first having topped them with a hoe made on purpose, and set at such an angle as to cut the beets off parallel, or at right angles to the axis of their growth.

I have done my loading so far by throwing the beets into the baskets, and emptying the baskets by hand into the wagons or carts; the beets then go to the factory, and are unloaded by a little hurdy-gurdy water-wheel, working as a hoist, that elevates the beets very quickly from the wagons and dumps them into the bins; the wagons are lined with a net, made on purpose, which, when raised on one side, throws the beets over to the other and directly into the bins. In this way I find no trouble in unloading, without any delay, 530 tons of beets per day with three men, which is a great saving of labor, time, and expense to the farmers, as there is no time lost and no hand work in unloading, and the beets are not nearly so much bruised or injured as would be the case in unloading with a fork, shovel, or any other instrument.

I expect to keep on continually improving, with the help of Mr. Martin and others in Chino, on all these methods, until the harvesting of the beets will be entirely done by machinery; that is, the beets topped, piled, and delivered in wagons, and ready to go into the factory, all hand work being done away with.

Thinning the beets, I anticipate, will have to be always done by hand; still, it is possible that we may be able to plant in hills, thus securing a good stand without the necessity of cleaning the beets out along the rows between those that are left; but, at present, as a complete stand is the first requisite to a good crop, I have considered it the safest to plant in drills, and put in plenty of seed.

It is anticipated that the inventive genius of the American people will be able partially, at least, to overcome, in the cost of production, the difference in the price of labor between this country and Europe.

I have now being shipped from Antwerp about 75,000 pounds of seed, which I expect to reach here by the first of January, when I shall immediately commence planting. In Southern California we are enabled to plant from the first of January to the middle of May, by commencing on the drier or uplands and following down toward the moister lands, until the latest time for planting has been reached, which I consider about the middle of May. This is a great advantage, as it enables the season of planting and thinning to be extended over this long length of time, so that one person can cultivate at least three times as much area as he can with the season and under the conditions of climate of the Eastern States and Europe. We have equally good advantages for the harvesting, as I expect, the coming season, to commence harvesting on the first day of July and run until the harvest is finished. The last campaign, just ended, commenced on the 11th of July and ended on the 8th of October, during which time we put in between 27,000 and 28,000 tons of sugar beets, all of which went through the factory and was worked up into sugar, the total amount of sugar shipped by the Chino Valley Beet Sugar Factory this last season being 7,903,000 pounds.

The late campaign was very successful and satisfactory, no trouble being experienced in either harvesting or working the beets. The beets

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were put into the factory at about the same rate that they were worked, and at no time did we find it necessary to have in the factory bins more than 700 or 800 tons of beets, thus enabling the factory to work the beets fresh from the fields, which is an advantage only fully appreciated by those who have experience in such matters, and the importance of which cannot be overestimated.

I believe that one of the most important uses to which an Experiment Station and the money to be spent by it can be used, is to diffuse knowledge of the cultivation of the sugar-beet, from the time the seed is put in the ground until the delivery of the beets at the factory and the sugar to the market. I should say that in addition to the information that can be diffused by the widely scattered Experiment Stations that the Government should employ experts, who could go among the different communities and plant experimental patches, analyze the beets, and teach the people what the raising and culture of the sugar-beet means, and what the possibilities are for a man who wishes to become interested in this new agricultural product, which, as a diversity of product, will be of great value to the whole agricultural interest of the Pacific Coast. I am convinced also, that when this question is understood, as it is in Germany and other parts of Europe, the coöperative principle can be better and more satisfactorily employed in this industry than in any other agricultural industry that we have, for the reason that the delivery of the beets to the factory and the sale of the product, as well as the receipt of the money, can be under the immediate eye of the farmers; and it is not necessary to ship this product before the farmer receives the result of his labor. The amount also of the beets necessary to run a 300-ton factory can be grown in a very small radius, and by a small community, thus keeping the thing within the bounds of control sufficient to enable all parties to understand and see how the working is going on to their satisfaction. Sugar is a product also, the market value of which is practically without fluctuation, which enables the farmer to calculate beforehand as to what the value of his crop will be, which, when obtained, is received in a few payments that can be used by him to the best advantage. It has also demonstrated that young orchards can be planted out to beets between the rows of the fruit trees and raise a crop of beets that will be but slightly less than if his trees were not planted. A Mr. Robinson, on the Chino Ranch, this year planted his young prune orchard to beets, which yielded him 22½ tons to the acre, of 15 per cent beets. Mr. Keyes, with his walnut orchard, did about as well, and many others that can be found upon the Chino lands.

In conclusion, I will say that in my opinion the Experiment Stations and the Agricultural Colleges cannot be employed in a more beneficial direction than in disseminating the knowledge of the cultivation of the sugar-beet. (Richard Gird.)

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III.

REPORTS ON ENTOMOLOGY AND PLANT DISEASES.

Studies from the Laboratory of Plant Diseases.

I. The Life History of the Woolly Aphis.

II. Studies in the Life History of a Puccinia found on Œnothera ovata.

III. Experiments upon the Effect of Hydrocyanic Acid Gas on Different Insects.

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STUDIES FROM THE LABORATORY OF PLANT DISEASES.

[These are the results of original investigations by students in the course of parasitic plant diseases. The work in this laboratory is designed to initiate the student into the methods of modern research, and for practical experience each undertakes for himself some original work. The term "Plant Diseases" is to be understood in its widest sense, and purely scientific subjects are considered, as well as those of immediate economic bearing.—C. W. Woodworth.]

1. THE LIFE HISTORY OF THE WOOLLY APHIS.

(*Schizoneura lanigera*, Hausm.)

By Kate Ruth Howell, Class of '93, U. C.

This insect is one of the most injurious pests known to the apple tree. It was supposed to have been introduced into Europe from America, but is now known to have existed in Europe from time immemorial. In some places, however, it exists only in one form, that is, either only above or only below the ground. From the earliest times writers have disagreed in regard to the identity or absence of identity between the root and aerial forms. The following is a review of the available literature of the subject:

THE TWO FORMS.

All the older writers on this insect, up to and including Harris, in 1852, believed that the root and aerial forms were identical. Fitch, in 1851, and later in 1856, described the root form, considering it different from the species hitherto described as infesting the trunks and branches, but, as was pointed out by Thomas in 1879, his specimen of the winged form evidently was not a true woolly aphis. Walsh, in 1866, declared that the forms were different, apparently following the decision of Fitch, and later, in answer to a correspondent in the "Practical Entomologist," he maintained emphatically that the forms are different genera; basing this distinction on the venation of the front wings and on their habitats. Riley, in his first report in 1868, also declared that the forms belonged to different genera, but said that a few of the root form might occasionally be found on the trunk and limbs. In his third report, however, in 1871, he says: "There is now every reason to believe that the two insects are identical, or that at furthest they can only be considered as varieties of one species. Upon the closest examination we cannot find the slightest difference between the root and the branch-inhabiting lice." He further remarks that in some places the insect is found almost entirely on the root, while in other places entirely upon the limbs; but this is due to a difference in climate and soil and not in the insect. Glover (1876) still believed that the forms were different specifically. Thomas (1879) reviewed thoroughly the literature on the subject and quotes that Walsh considered the forms different genera, but

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he himself believes them to be identical. He thinks, though, that the species may undergo all its changes and pass all the seasons on the trunk and not descend to the roots. Cooke (1881) merely mentions the insect as living on the trunk and going downwards as far as the root, thus evidently believing them identical; and all subsequent writers seem to have taken for granted that the forms are of the same species; but from the statements it would be impossible to say whether the insects were structurally different or not.

WINGED FORMS.

According to the older writers, Hausmann and Knapp, as quoted by Harris in 1852, the adult insects never acquire wings. Winged forms, however, were known and described in Europe long before they were in America, but the literature is not accessible. Fitch (1856) was the first of our authors to describe the winged insect. His insect was supposed to be a root form, but, as was pointed out above, evidently was a wrong specimen. Walsh (1866) seems to have been acquainted with the true winged stage of one or the other forms, as he maintained a generic difference between his insect and that described by Fitch. Riley, in 1869, figures and describes a winged form from the root. Glover (1876) gives a very small and unsatisfactory figure of a winged aerial form. The only other figure of this appears in Saunders' "Fruit Insects," in 1883, but there has been no published description of the aerial winged form; and, although Saunders' figure differs from the description of the winged root form, the differences, manifestly, are due to inaccuracy in drawing. Thomas gives another careful description of the winged root form, which agrees with that of Riley. Packard (1883) merely mentions winged males and females, and French (1891) figures both, but the figures are too inaccurate to be relied upon.

EGGS.

Harris (1852) says there are eggs deposited in the crotches of the branches or in the bark near the ground, but they are so small as not to be seen by the naked eye. Fitch (1856) believes that the winged female lays eggs on the root. Glover (1876) says that the winged aerial female flies from tree to tree to deposit eggs. Thomas (1879) speaks of the winged form laying eggs, but later, he says, that judging from analogy, the winged female is viviparous. All subsequent authors, when they have said anything about the eggs, have quoted one or the other of these conclusions. Judging from the vague and indefinite statements made by the earlier writers about the eggs, and from the fact that later observers have not seen an egg, it appears doubtful that they ever have been seen.

OBSERVATIONS—THE TWO FORMS.

Specimens both of the aerial and root forms have been collected, mounted, and examined at different times. For mounting they were treated with alcohol, then oil of cloves, and then placed in the center of a drop of balsam on the slide and covered with the cover glass. Mounts were also made with caustic potash. Not the slightest structural difference could be found between the insects taken from the roots and those

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from the branches. Further, the root and aerial forms are interchangeable. Experiments proving this fact were performed in the following manner: Young seedling apple trees were planted in a pot, in soil that was impregnated with the woolly aphis taken from a branch of an apple tree, and placed in the greenhouse. After ten days an examination showed the insects alive and well, scattered through the soil, but mostly clinging to the roots.

STAGES OF WINGLESS FORM.

Among the specimens of the wingless insect mounted four stages were observed, differing plainly from one another in the width of head between the eyes, and the length of the antennæ. Careful examination of numerous fresh specimens showed no other stage. The most striking characteristic difference between the stages, and, in fact, the only changes that can be accurately determined, are the variations in size of the corresponding harder portions of the animal structure. Measurements were taken of the joints in the antennæ, the joints of the middle leg, and the width of the eye in each stage.

In the first stage the antennæ contained five joints, the length of each, respectively, from the head being, .0238, .03808, .05236, .05236, .05712 millimeters; eye measures, .0285 mm.; joints of middle leg from body, .0476, .1428, .12852, .0238, .0666, .0238 mm. In the second stage the antennæ are six-jointed, a short joint having developed out of the elongated third joint, and being between the third and fourth joints. Measurements: Antennæ, .0333, .03808, .06188, .0285, .05236, .06188 mm.; eye, .0333 mm.; middle leg, .0666, .18564, .1428, .0234, .0666, .0238 mm. In the third stage the joints have grown only proportionately longer: Antennæ, .03808, .0476, .0666, .0333, .06188, .07136 mm.; eye, .03808 mm.; middle leg, .08564, .27132, .26656, .02856, .08088, .0238 mm. In the fourth stage, the adult, antennæ, .05236, .05236, .13804, .0476, .07612, .08088 mm.; eye, .0476 mm.; middle leg, .0952, .3332, .3047, .0285, .08088, .0238 mm.

WINGED FORM.

Two stages of the winged insect were found on the root, one having wing pads, the other fully developed wings. Of the first the antennæ measured .05712, .0476, .2142, .0666, .0904, .0952 mm.; eye, .0333 mm.; middle leg, .0952, .34748, .3332, .0285, .05236, .0238 mm. Winged stage, antennæ, .0476, .05782, .27608, .0952, .10472, .09996 mm.; eye, .1190 mm.; middle leg, .14756, .4046, .46648, .0238, .0952, .07602, .0238 mm.

The description of the winged insect agrees with that of Riley (1869): "Antennæ two fifths the length of the body; joints 1 and 2 almost confluent, short and robust; joint 3 fully one half the entire length of the antennæ; joints 4–6 subequal—5 a little the longest, 6 a little the shortest. Wings hyaline; costal and subcostal veins robust and black; stigma pale brown, two and three fourths to three times as long as wide, pointed at both ends, the vein bounding it behind robust and black. Discoidal veins and stigmal veins slender and black, the third or forked discoidal hyaline and subobsolete on its basal one third. Length to tip of closed wings, .13–.14 inch."

A winged insect, which had the same structural form and the same venation of the wings, was found on a branch of the tree. The measure-

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ments of the joints of the antennæ and leg were much larger, but this difference probably is due to the sex, this appearing to be a male.

REPRODUCTION.

In regard to reproduction, we believe that the winged and wingless forms are always viviparous. In the body of the winged insect four or five embryos were clearly distinguished, and the wingless female gave birth to a young insect while being examined.

CONCLUSION.

In conclusion, as a general resumé, we believe that (1) the form inhabiting the root is identical in every particular with that inhabiting the stem and branches; (2) there are winged males and females both below and above ground; (3) as far as recent observation has shown there are four stages leading up to the wingless insect, and two to the winged, the pupa and adult; and (4) the young are produced alive.

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2. STUDIES IN THE LIFE HISTORY OF A PUCCINIA FOUND ON ŒNOTHERA OVATA.

By WALTER C. BLASDALE.

During the spring of 1891 my attention was attracted by a number of plants of *Œnothera ovata* on the University grounds that seemed to be afflicted with some form of fungoid disease. An examination showed the leaves to be completely covered with the orange-colored sori of the æcidial stage of some fungus. As time went on the disease spread with remarkable rapidity, and soon a large portion of the entire plot was more or less affected by it. The leaves of such plants lost their healthy green color, began to curl up, withered, and finally died; the roots blackened and began to rot, and hundreds of plants were thus killed outright.

During the succeeding year the same cycle of changes was observed, although the number of plants thus affected was not as great as in the previous year. Material was then collected for a more systematic study of this parasite, and a series of observations and experiments inaugurated.

The fungus, to which this disease is due, seems to be the *Puccinia œnothera*, first described by Vize, who found it on the leaves of *Œnothera Fremonti* and *strigosa*.

The æcidial stage, which is the most prominent one of the whole life history, makes its appearance early in the spring on the first plants that start into active growth after the winter rains. The peridia appear on both surfaces of the leaves, though far more abundant on the upper, and are so plentiful that but little actual surface of the leaf is left unaltered. They are from 2–3 mm. in diameter, and barely project above the surface of the leaf; the border is whitish, coarsely and irregularly split, spreading and scarcely recurved; spores are subglobase, smooth, orange in color, and about 18 μ in diameter. Intermingled with the peridia, are found a considerable number of spermagonia, and an infected plant at this stage gives off the musky ordor that has been attributed to the presence of these organs.

The uredo spores (Fig. 3) make their appearance only in the sori of the teleuto stage, and one may examine many leaves before finding a single uredo spore. It is evident that this stage is of but little importance in the life history of the fungus.

The teleuto sori make their appearance in two different positions, viz.: on both sides of the leaves of plants that have been infested with the æcidial stage, or upon the upper surface of the ovate leaves of the hitherto unaffected plants. In the latter position they always form reddish-colored spots; in the former, this is seldom the case. The spores break through the epithelium in the form of dense brown masses that are at first surrounded by the ruptured epidermal cells, but soon become free. They are oblong, or elliptic-oblong, in shape, strongly septate,

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slightly thicked at the apex, and measure, on an average, 22x40μ. The pedicels are short and thick.

These characters may serve to show the distinctions between this fungus and the more widely known *Puccinia epilobii* of De Candolle. That it is the *Puccinia œnothera* of Vize is a matter of some question, since the original description of that species is too brief and indefinite to be of much service, and authentic specimens are not available.

Other facts that bear a more or less important relation to the subject in hand are the frequent occurrence in this vicinity of an æcidium on the lower surface of the leaves of *Zauschneria Californica*, which, in every respect, answers to the description of the æcidium of *Puccinia epilobii;* also, in the vicinity of San Francisco, I have found a uredo on the leaves of *Œnothera spiralis* that does not seem to differ from the uredo spores found in the teleuto sori of the fungus under consideration. These facts at once suggest the possibility that all the above mentioned uredineæ are one and the same species, but become modified slightly according to the host plant on which they are found.

The only possible method of answering this question was by a systematic series of culture experiments, and an attempt was made to carry these out. As a starting point it was necessary to determine the exact relation existing between the æcidia and teleuto stages, as found on *Œnothera ovata.* This was accomplished by sowing the æcidia spores on the surface of healthy leaves, the latter being maintained under as nearly normal conditions as possible.

In this, as in all the other culture experiments undertaken, an inexpensive and most effective form of moist chamber was improvised by the use of the round glass lantern chimneys, such as may be procured in almost any hardware store. These were placed in shallow vessels containing water, and were covered with ordinary drinking glasses of such a size as to readily fit the outer rim of the chimney. Within the chamber thus prepared was placed a homeopathic phial, filled with water, and containing the leaf under treatment. This method proved to be a most successful one, since it admitted of an easy handling and frequent examination of the leaves, and is far less liable to the inaccuracies of the usual method of culture on potted plants. Many of the leaves of *Œnothera ovata* were maintained in this condition for a space of six weeks, and, before the end of that time, had sent out roots from the lower end of the petioles, thus forming independent plants.

In the first series of experiments a number of apparently uninfected leaves were painted with a band of water that had been charged with æcidia spores, and were placed under the conditions above named. A number of these leaves were affected by a rot that attacked the petiole and lower portion of the leaf blade, but of the six that escaped this misfortune two gave good results. At the end of the third week from the date of infection one showed two and the other nine sori of a dark brown color, that proved upon examination to consist of teleuto spores of the same size, shape, and color as those occurring naturally. There yet remained the possibility that these sori came from the mycelium already within the leaf tissue. For the next series of experiments, therefore, leaves were procured from a district a mile distant from any infected plants. Three of these leaves were infected, as in the former case, this time marking the exact portion of the leaf treated by a series of punctures, while three others were sown in a similar manner with

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teleuto spores. Of the first series two failed to produce any visible results, but on the third there were found at the end of three weeks no less than fourteen well-developed sori, all of which were situated within the narrow band that had been sown with spores. The leaves treated with teleuto spores failed to develop any sori. A single experiment was also made by placing a leaf in water containing teleuto spores, but at the end of six weeks no visible result had been produced. Having thus determined the relation existing between the different stages found on *Œnothera ovata*, it next remained to introduce the other elements, viz.: the æcidium on *Zauschneria Californica*, and the uredo on *Œnothera spiralis*, and to determine the relation existing between them and the *Puccinia œnothera*. With this idea in view, forty-three experiments were made, using the leaves of *Œnothera ovata*, *biennis*, *odorata*, and *grandiflora*, *Zauschneria Californica*, and *Epilobium Franciscanum*, and treating with the spores from *Œnothera ovata* and *Zauschneria Californica*. Unfortunately, it was impossible to obtain the uredo spores from *Œnothera spiralis* at the time the experiments were made. The result of this series of experiments was uniformly negative, *i. e.*, in no case could I obtain proof of the growth of either of these fungi on a host plant differing from the one on which it occurred naturally. Even the leaves of *Œnothera biennis* failed to develop teleuto sori when treated with the æcidia spores from *Zauschneria*, although this plant is frequently affected with *Puccinia epilobii* in the Eastern States. Though far from proving that there is no relation existing between these various fungi, these experiments seem to render it probable that each one is a distinct species.

A consideration of these results taken, together with such observations as I have been able to make, seem to show that the life history of this fungus stands something as follows: The mycelium of the æcidia stage continues to produce spores, and to develop within the tissue of the host plant until the death of the latter is effected. The spores thus produced falling upon healthy plants germinate and produce a crop of uredo and teleuto spores, the number of which is governed largely by climatic conditions, particularly temperature and moisture. The thick-walled teleuto spores remain on the ground or amongst the withered leaves during the dry season, and are ready to seize upon the young leaves of the succeeding season, and ultimately produce the death of the plant. It would thus appear that only plants of at least two seasons' growth could be affected with the æcidial stage, and this seems to be in accordance with my observations.

An attempt was also made to work out the histological structure of the diseased leaves with special reference to the relation of the mycelium to the leaf cells and the formation of the sori. For this purpose serial sections were made of affected leaves in their different stages of development by the use of a Cambridge rocker microtome. The tissue was killed by a variety of methods, but ordinary cold alcohol seemed to give the best results. After hardening with alcohol, the leaves were stained either with saffranin or with a mixture of saffranin, fuchsin, and methyl-violet, and after the usual treatment were embedded in soft parafin. In spite of all possible care used in carrying out the details of the process, it was found impossible to obtain an entirely satisfactory condition of tissue. In nearly all cases the cells were so distorted as to render it difficult to determine their exact shape and relations.

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A rather unexpected result was obtained by the use of saffranin as a stain, for it was found that this reagent was capable of producing a more or less differential effect when used on the diseased tissue. In nearly all the sections that had been treated with the stain there was found to be two kinds of tissue having pronounced differences in color and structure. The first was the ordinary parenchyma of the host plant, and had a dull red color, while the second consisted of a number of thread-like convoluted filaments of a bright wine color that were scattered throughout the leaf tissue. There seems to be but little doubt that this latter tissue was the mycelium of the fungus itself, though absolute demonstration of the fact is wanting, and other sections treated with different stains give a different appearance of the mycelium. Owing to the condition of the tissue it was found impossible to determine the exact relation of this special mycelium to the leaf cells, but some few points of interest were made out. It was found that nearly all this tissue appeared only near the ventral surface of the leaf amongst the loosely compacted cells of that area. These filaments were seldom found at any great distance from the sori themselves, though in no case were they seen to culminate in the sori. One of the remarkable features was their great size, for many were found that had diameters equal to a third of the width of the smaller cells. Their convolutions were in some cases quite marked, though it would be difficult to determine this further relation. In some cases the æcidia spores themselves had received the stain in much the same manner as the filaments, and the tissue immediately surrounding the sorus was often colored in a like manner, though never as deeply. Owing to the complexity of the tissue at this point it was found impossible to ascertain its exact structure, or even to show that it was composed of these filaments.

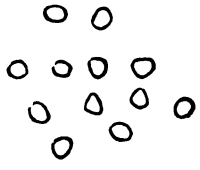

Fig. 1.

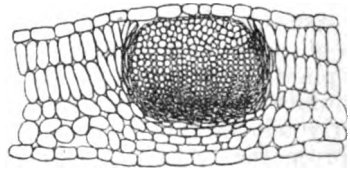

Fig. 2.

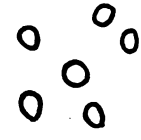

Fig. 3.

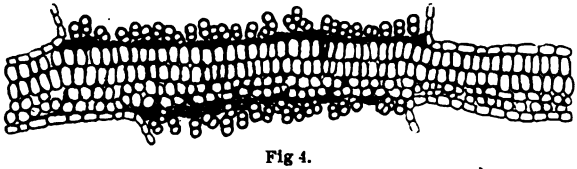

Fig 4.

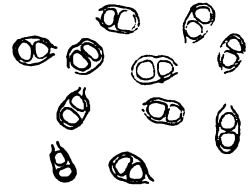

Fig. 5.

PUCCINIA ON ÆNOTHERA OVATA, VIZE.

Fig. 1. Æcidia spores. Fig. 2. Section through an æcidia sorus. Fig. 3. Uredo spores Fig. 4. Section through teleuto sorus. Fig. 5. Teleuto spores.

A sketch of the typical leaf structure of this plant is seen at the ends of Figs. 2 and 4. Starting from the dorsal surface, it will be seen that there is a sample row of epithelial cells, beneath which are two rows of narrow, elongated cells. Below these comes a loose indefinite layer, two or three

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cells deep, and finally the epithelial layer of the ventral surface. By a reference to these drawings it will be found possible to trace the changes that go on in the process of development of the æcidia sorus.

All the sections of the younger sori show that this body originates in the space between the epithelial layer and the first row of elongated cells. It first appears as an indefinite, thickened mass; that in unstained sections has a pronounced yellow color. As it develops, this mass increases in size, assumes a spheroidal shape, and pushes down the inner tissue of the leaf. It would seem that during this process, the entire four layers below the sorus are crowded into the small space normally occupied by two. In all well-developed sori, four distinct rows of cells could be counted between the base of the sorus and the epithelial layer, and these rows were indicated by thickened lines that were evidently the collapsed walls of the partly destroyed cells. After the sorus has attained a considerable size, it extends itself by laterally pressing on the adjoining tissue and destroying several rows of cells, whose remains form an indefinite layer that immediately surrounds the peridium. The entire cell structure surrounding the peridium thus suffers considerable distortion both through the abstraction of the protoplasmic contents and the pressure exerted by the growing sorus. Short pieces of the peculiar mycelium mentioned above, were in all cases to be found at short distances from the sorus.

The tissue of the peridium itself seems to consist of a single row of simple oblong cells much smaller than any of those found in the leaf tissue. Most of the sections prepared represent this tissue as consisting of a broad band of small yellowish cells, but this is probably due to the fact that these sections are, to some extent, tangential, and therefore represent several rows of cells.

The spores originate entirely from the indefinite mass of tissue that occupies something like a half of the diameter of the base of the sorus. They first appear in the form of minute round bodies arranged in parallel lines that gradually increase in size as they approach the upper part of the sorus, and in a fully developed one becomes much angulated and independent of any order of arrangement. A cross-section of a mature sorus, just before it bursts through the epithelium, shows the inner space to be densely packed with these bodies, and it is this crowding that is, in all probability, responsible for their angularity.

I have tried to represent these various points in Fig. 2, which was drawn from a camera lucida sketch, though many of the minor details were afterward added from a comparison with other sections. The appearance of the æcidia spores is shown in Fig. 1.

It is to be observed that the sorus does not break through the epithelium until a large part of the spores contained within it are mature. It then bursts through this tissue in a great number of radiating lines, leaving the epithelium in the form of a white, erect border.

The structure of the teleuto sorus is far less complicated. Like the æcidia sorus, it originates in the space between the epithelial layer and the first row of elongated cells. There is nothing like the definite structure of a peridium produced, but only a thickened mass of mycelium that collects together and gives rise to the teleuto spores. The mass of spores thus formed finally becomes so extensive as to burst off the enveloping epethelial layer, and it was noted that this takes place from a single point, and, at first, forms three triangular divisions. Having once

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started, this process of spore-forming continues for some time, for the sori gradually increase in size, and continue to produce dense brown masses of these bodies.

In many cases the sori appear at opposite points on the two sides of the leaf, and it was thought that a connection between the two mycelial layers could be traced. The included tissue is often slightly modified, both in the size of the cells and in their contents. Fig. 4 gives an idea of the structure of this kind of sorus, though as in the former case it is to a great extent compiled from a number of sections.

The appearance of some of these spores is shown in Fig. 5.

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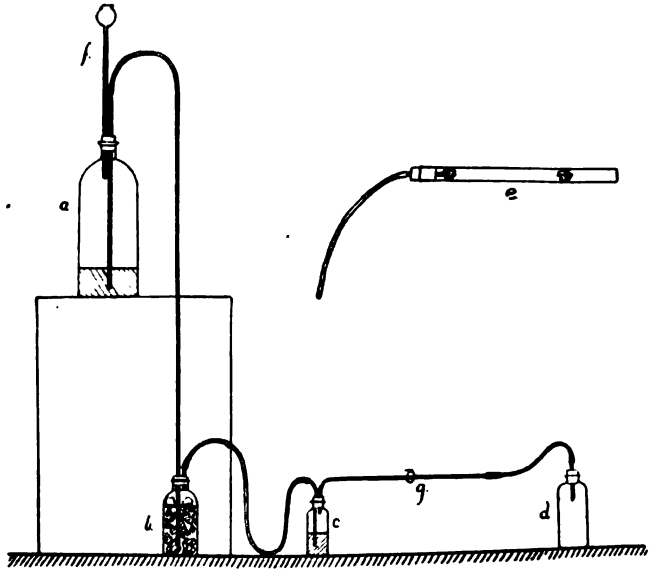
3. EXPERIMENTS UPON THE EFFECT OF HYDROCYANIC ACID GAS ON DIFFERENT INSECTS.

By Richard Schmidt.

On account of the importance the hydrocyanic acid gas treatment has attained during recent years, and because so little is known as to the relative effects of the gas upon different insects, it has seemed desirable to undertake a set of experiments to establish a few facts concerning its action.

For this purpose the apparatus used consisted of a large bottle placed upon a box and partially filled with dilute sulphuric acid, the latter siphoning into the bottle *b*, which contains the potassium cyanide placed on pieces of glass so as to keep it near the top of the bottle. The gas which is generated in *b* passes through a rubber tube to the wash bottle *c*, which acts as an indicator and also prevents any air passing back into the generator *b*; *g* is a stopcock, and *d* the bottle into which the insects were put.



Apparatus for Experimenting with Hydrocyanic Acid Gas.

The apparatus is charged through the tube *f* and the stopcock opened so as to allow the gas to escape until it is certain that all the air is driven out of the apparatus. Then the stopcock is closed.

The insects are put into bottle *d* and the latter tightly corked. The gas is now allowed to flow until the pressure is equalized.

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The distance from the level of the liquid in *b* to that in *a* is about 15 inches. Then, as the pressure of the atmosphere equals the weight of a column of 39.9 of water, the pressure in the apparatus is approximately the ratio of 39.9 to 1.25, or 3.6 per cent more than the atmosphere. The amount of gas in *d* will be therefore very near to 3.6 per cent. It might be supposed that there would be a lack of uniformity in the diffusion of the gas, but practical experience shows that this is not the case, for certain flies were affected very uniformly and quickly, as is shown in the tables below.

The apparatus at *e* was used in the experiments with pure gas. It consisted of a large tube, into which the insects were placed and which was stopped at both ends with a cotton plug. One end of this tube is placed in water and the gas passed through until it is certain that all the air has been driven out.

Below are shown the results of the experiments in detail. The first column gives the number of the experiment. The second, third, and fourth show the time that elapsed before the insects were affected by the gas, then before they seemed to be dead, and the entire time that the treatment was continued. The final results of the treatment are given in the last column.

Name.	No. of Experiment.	Affected.	Seems Dead.	Treatment.	Final Results.
		Minutes.	Minutes.	Minutes.	
Hymenoptera.					
Tenthredinidæ—					
Hoplocampa sp?	44	4	10	12	Dead.
Monophadnus sp?	31	4	10½	13	Alive.
Diptera.					
Stratomyidæ—					
Sargus sp?	26	4	5	8	Alive.
Leptidæ—					
Leptus sp?	32	3	4½	13	Alive.
Leptus sp?	33	2	11	13	Alive.
Leptus sp?	34	3½	5	13	Alive.
Anthomyidæ—					
Sp?	8	1	2	3	Alive.
Sp?	22	1	2	3	Alive, but dead next day.
Sarcophagidæ—					
Sp?	11	1	2	3	Alive.
Dexidæ—					
Dexia sp?	4		2	16	Dead.
Dexia sp?	9	2	2	3	Alive.
Dexia sp?	10	1	2	3	Alive.
Dexia sp?	17	1	2	3	Dead.
Dexia sp?	18	1	2	3	Dead.
Dexia sp?	19	1	2	3	Dead.
Dexia sp?	20	1	2	3	Dead.
Dexia sp?	21	1	2	3	Just alive.
Helomyzidæ—					
Sp?	45	½	1	12	Dead.
Sp?	35	1½	2½	13	Alive.
Sp?	36	1	2	13	Alive.
Lepidoptera.					
Papilionidæ—					
Pieris sisymbrii	38	5	10	12	Dead.
Pieris sisymbrii	39	5	10	12	Alive.

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Name.	No. of Experiment.	Affected.	Seems Dead.	Treatment.	Final Results.
		Minutes.	Minutes.	Minutes.	
Coleoptera.					
Carabidæ—					
Promecognathus lævissimus	13			57	Alive.
Promecognathus lævissimus	13	57	68	68	Alive.
Platynus ovipennis	1	5	10	16	Dead.
Platynus ovipennis	2	5	10	16	Dead.
Platynus ovipennis	5	5	10	16	Dead.
Platynus ovipennis	6	9	20	31	Alive.
Platynus ovipennis	6	5	6	57	Dead.
Platynus ovipennis	47	4	8	12	Dead.
Platynus ovipennis	48	4	8	12	Dead.
Platynus ovipennis	49	4	8	12	Dead.
Platynus ovipennis	50	4	9	12	Dead.
Platynus ovipennis	51	2	18	20	Dead.
Platynus ovipennis	52	2	9	20	Dead.
Platynus ovipennis	53	2	15	20	Dead.
Platynus ovipennis	54	2	16	20	Dead.
Pterostichus vicinus	12	7	19	57	Dead.
Amara conflata	7	9	11	16	Alive.
Amara conflata	7	12	21	57	Dead.
Coccinellidæ—					
Chilocorus bivulneris	24	3	4	8	Dead.
Coccinella californica	23	3	4	8	Dead.
Chrysomelidæ—					
Gastroidea dissimilis	42	6½	10	12	Dead.
Syneta albida	25	3	4	8	Alive.
Tenebrionidæ—					
Coelocnemis obesus	14			57	Alive.
Coelocnemis obesus	14			68	Alive.
Coelocnemis obesus	15			57	Alive.
Coelocnemis obesus	15			68	Alive.
Hemiptera.					
Capsidæ—					
Sp?	29	3½	4½	13	Alive.
Sp?	30	2½	11	13	Alive.
Sp?	40	1	3	12	Dead.
Sp?	41	1	3	12	Dead.
Orthoptera.					
Gryllidæ—					
Sp?	3	8	11	16	Alive.
Neuroptera.					
Perlidæ—					
Sp?	43	9	10	12	Dead.

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Name.	Number of Species.	Number of Experiments.	Affected.		Seems Dead.		Final Results.	
			Minimum Time.	Maximum Time.	Minimum Time.	Maximum Time.	Alive. Maximum Time.	Dead. Minimum Time.
			Minutes.	Minutes.	Minutes.	Minutes.	Minutes.	Minutes.
Hymenoptera.								
Tenthredinidæ	2	2	4	4	10	10½	13	12
Diptera.								
Stratomyidæ	1	1	4	4	5	5	8	
Leptidæ	1	3	2	3½	4½	11	13	
Anthomyidæ	2	2	1	1	2	2	3	3
Sarcophagidæ	1	1	1	1	2	2	3	
Dexidæ	1	8	1	2	2	2	3	3
Helomyzidæ	2	3	½	1½	1	2½	13	12
Diptera orthorapha	2	4	2½	4	2½	11	13	
Muscidæ calypteræ	4	11	1	2	2	2	3	3
Muscidæ acalypteræ	2	3	½	1½	1	2½	13	12
Total for Diptera	8	18	½	4	1	11	13	3
Lepidoptera.								
Papilionidæ	1	2	5	15	10	10	12	12
Coleoptera.								
Carabidæ	4	18	2	57	6	68	68	12
Coccinellidæ	2	2	3	3	4	4		8
Chrysomelidæ	2	2	3	6½	4	10	18	12
Tenebrionidæ	1	4					68	
Total for Coleoptera	9	26	2	57	4	68	68	8
Hemiptera.								
Capsidæ	2	4	1	3½	3	11	13	12
Orthoptera.								
Gryllidæ	1	1	8	8	11	11	16	
Neuroptera.								
Perlidæ	1	1	9	9	10	10		12
Grand total for all	24	54	½	57	1	68	68	3

Two species of the family Tenthredinidæ represent the order Hymenoptera in these experiments, and show considerable difference in the effect of the gas, although no more than might be expected with two different genera.

The order Diptera is represented by six families; Stratomyidæ, with but a single specimen; Leptidæ, where there was considerable difference noticed in the one species used, though in no case was the treatment long enough to kill the insect; Anthomyidæ, with two species, both of which were affected very quickly, and though they both came to life, the death of one within twenty-four hours was evidently from the effect of the gas; Sarcophagidæ, the one species of which, like all the related families, was affected very quickly; Dexidæ, of which a considerable series of one species was studied, the results of which are well shown in the table; and the family Helomyzidæ, with two species, which were found to be insects easily affected, but requiring a long treatment to kill them. Considering the order as a whole, we find, as is shown in the

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second table, that the orthoraphous Diptera are not affected as soon as the others, and also requires more time to kill, and that of the cyclorapha we find among the calypterous families the other extreme.

Of the Lepidoptera, but one species of the family, Papilionidæ, is represented. The treatment in this case seems to have been about on the limit between fatal and ineffectual.

Four families of the order Coleoptera were used in these experiments. Of the four species of the family Carabidæ, one, *Promecognathus lævissimus*, was treated twice, not having been killed the first time, and even this second treatment was not enough; the second, *Platynus ovipennis*, shows an extreme amount of variation, even 12 minutes being enough in one case, while in another case 31 minutes was not. The third species was probably given a longer treatment than necessary, while the fourth had to be treated a second time. Two species of the family Coccinellidæ show that these insects are easily killed, and the same is the fact apparently in the family Chrysomelidæ. If the species experimented with is a fair sample of the family Tenebrionidæ, it includes the insects the most difficult to kill.

The Hemiptera were represented by two species belonging to the family Capsidæ, and very closely allied. There was considerable variation, however, in the effect of the treatment.

The one example of the order Orthoptera was not treated long enough to give any results.

Finally, the Neuroptera were represented by a single species, which succumbed to the treatment.

Of all the orders of insects, the Diptera was the easiest killed, and the Coleoptera presents the greatest amount of variation in this respect.

Although these experiments were not as extensive as might be wished, still they point unmistakably to the following two important conclusions. The first is, that the extreme amount of variation in one species, *Platynus ovipennis*, shows that the physical condition of the insect has a great deal to do with the time required to kill it, and emphasizes the necessity of a better knowledge of the physiology of insects before we may expect the best results in the use of the gas, and possibly of all other insecticides.

The second and most important conclusion arrived at, and of special significance in the economic application of the gas, is the fact that the ladybirds (Coccinellidæ) are most easily killed, and among the Diptera the series of families which includes the parasitic forms are the most easily killed of all insects. This shows the necessity of very thorough treatment wherever gas is used for the destruction of scale insects, for otherwise the destruction of the ladybirds may counterbalance the good done in killing the scales.

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APPENDICES.

I. Methods of Physical and Chemical Soil Analysis. By E. W. Hilgard.

II. Synopsis of the Diseases of Cultivated Plants. By C. W. Woodworth.

III. Synopsis of the Families of Insects. By C. W. Woodworth.

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THE METHODS OF PHYSICAL AND CHEMICAL SOIL ANALYSIS

By E. W. Hilgard.

[The detailed presentation of the methods of soil examination pursued in the laboratory of this Experiment Station is here given for the benefit both of the Stations of other States, and for that of other chemists who are called upon to make such investigations in response to demands from farmers. Unification in the methods to be employed in soil examination is so absolutely essential to its practical usefulness, that without it the work and expense may be essentially wasted. It should be distinctly understood that the purpose of soil analysis is not to learn the ultimate composition, but to ascertain what proportion of the elements of plant food may become available to plants within the time limits that interest the present generation. The *ultimate* composition, or even that portion yielding to any solvent agency greater or weaker than that exercised by plants, is of no interest to the agriculturist.]

Before entering upon the details of physical and chemical soil investigation, it may not be superfluous to define what are the objects to be accomplished in such investigations, both from the standpoint of the farmer and of the agricultural expert.

It is well understood that in the present state of knowledge, the chemical analysis of soils long cultivated and fertilized affords, alone, but a limited amount of information regarding their productive powers, although always useful in defining their general character and obvious deficiencies. In the case of those cultivated *without* fertilization, even for a considerable length of time, chemical analysis will afford us valuable indications not only regarding their general character, but also in respect to the important soil ingredients most likely to have been reduced below the level of profitable culture. Yet, so long as virgin spots fairly representing cultivated lands exist, the results obtained by the examination of the former can be fruitfully applied to the latter.

In virgin soils the indications, as experience has shown, become so definite as to permit a close forecasting not only of the general character and value of lands not yet brought under cultivation, but also of their best adaptations, and of the probable duration of productiveness without fertilization. Chemical analysis can thus, when combined with the physical, geological, and botanical examination of soils, give information of such direct practical importance, that in the newer States and in the Territories it becomes a reliable guide to the settler in the choice of lands and cultures. Such work is therefore peculiarly the province of the Experiment Stations west of the Mississippi River.

As regards physical soil analysis as practiced in Europe, its results have fallen far short of the expectations which, theoretically, it might be expected to fulfil, viz.: The definite measurement of the "tilling qualities," and of other physical coefficients of soils. The judgments regarding these points deducible from the great majority of mechanical soil analyses as usually made and published, afford hardly more information than could be derived from mere hand tests on the dry and wet soil. Yet it is hardly doubtful that a proper study of the physical composition can be made to yield a much deeper insight into the functions of the several physical soil ingredients, and consequently, into the means of modifying the physical properties to the best advantage.

One important function of such examinations (about the feasibility of which there can be no reasonable question) is the identification of uncultivated soils with those of lands already under cultivation; thus permitting the application of experience already acquired, to new lands.

But in order to attain such results, not only must the mode of sampling in the field, the preparation of the samples for analysis, and the physical and chemical analysis itself, be conducted upon a well-considered and uniform system, but the conditions of occurrence, the "lay," depth, climate, natural vegetation, etc., must be known as fully as possible; since all these factors must be taken into consideration in interpreting for practical purposes the results of the physical and chemical examination. Moreover, in determining the conditions to be fulfilled, and the *modus operandi*, all arbitrary conventions should be avoided as much as possible; since all such are sure to be violated sooner or later by workers who consider themselves as much entitled to exercise of judgment as any one else. In developing the methods originally suggested by D. D. Owen, I have therefore sought to establish a rational basis inherent in the nature of the case, as far as possible, and to determine maxima or minima rather than arbitrarily assumed means. The detailed motivation of all these points would increase this report far beyond the admissible limits; but references are given to the publications in which such points are discussed.

I have also, for brevity's sake, omitted a detailed description of the manipulations in the case of well-known analytical methods, mentioning only some critical points upon which success depends, but taking for granted the following out of the accepted precepts.

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THE SAMPLING OF SOILS.

Since the practical utility of soil work would be greatly impaired were it dependent only upon the personal exploration of the wide domain by the Experiment Station officers, I have formulated, and long used successfully, the following "Directions for taking Soil Samples," that are forwarded either to persons desiring information as to their lands, or to intelligent farmers residing in regions of which the soils are to be investigated. It is often surprising how accurate and graphic are the data so obtained:

"In taking soil specimens for examination, the following directions should be carefully observed—always bearing in mind that the analysis of a soil is a long and tedious operation, which cannot be indefinitely repeated:

"*First*—Do not take samples indiscriminately from any locality you may chance to be interested in, but consider what are the two or three chief varieties of soil which, *with their intermixtures*, make up the cultivable area of your region, and carefully sample these, first of all; then sample your particular soil with reference to these typical ones.

"*Second*—As a rule, and whenever possible, take specimens only from spots that have not been cultivated, nor are otherwise likely to have been changed from their original condition of 'virgin soils,'—*e. g.*, not from ground frequently trodden over, such as roadsides, cattle-paths, or small pastures, squirrel holes, stumps, or even the foot of trees, or spots that have been washed by rains or streams, so as to have experienced a noticeable change and not be a fair representative of their kind.

"*Third*—Observe and record carefully the normal vegetation, trees, herbs, grass, etc., of the average land; avoid spots showing unusual growth, whether in kind or quality, as such are likely to have received some animal manure, or other outside addition.

"*Fourth*—Always take specimens from more than one spot judged to be a fair representative of the soil intended to be examined, as an additional guarantee of a fair average.

"*Fifth*—After selecting a proper spot, pull up the plants growing on it, and scrape off the surface *lightly* with a sharp tool, to remove half decayed vegetable matter not forming part of the soil as yet. Dig a vertical hole, like a post-hole, at least 20 inches deep. Scrape the sides clean, so as to see at what depth the change of tint occurs which marks the downward limit of the surface soil, and record it. Take at least half a bushel of the earth above this limit, and on a cloth (jute bagging should not be used for this purpose, as its fibers, etc., become intermixed with the soil) or paper, break it up and mix thoroughly, and put up at least a quart of it in a sack or package for examination. This specimen will, ordinarily, constitute the 'soil.' Should the change of color occur at a less depth than 6 inches, the fact should be noted, but the specimen taken to that depth nevertheless, since it is the least to which rational culture can be supposed to reach.

"In case the difference in the character of a shallow surface soil and its subsoil should be unusually great—as may be the case in tule or other alluvial lands, or in rocky districts—a separate example of that surface soil should be taken, besides the one to the depth of 6 inches.

"Specimens of salty or 'alkali' soils should, as a rule, be taken only toward the end of the dry season, when they will contain the maximum amount of the injurious ingredients which it may be necessary to neutralize or wash out.

"*Sixth*—Whatever lies beneath the line of change, or below the minimum depth of 6 inches, will constitute the 'subsoil.' But should the change of color occur at a greater depth than 12 inches, the 'soil' specimen should nevertheless be taken to the depth of 12 inches only, which is the limit of ordinary tillage; then another specimen from that depth down to the line of change, and then the subsoil specimen beneath that line.

"The depth down to which the last should be taken will depend on circumstances. It is always necessary to know what constitutes the foundation of a soil, down to the depth of 3 feet at least, since the question of drainage, resistance to drought, etc., will depend essentially upon the nature of the substratum. But in ordinary cases, 10 or 12 inches of subsoil will be sufficient for the purposes of examination in the laboratory. The specimen should be taken, in other respects, precisely like that of the surface soil; while that of the material underlying this 'subsoil' may be taken with less exactness, perhaps at some ditch or other easily accessible point, and should not be broken up like the other specimens.

"*Seventh*—All peculiarities of the soil and subsoil, their behavior in wet and dry seasons, their location, position—every circumstance, in fact, that can throw any light on their agricultural qualities or peculiarities—should be carefully noted, and the notes sent with the specimens. Unless accompanied by such notes, specimens cannot, ordinarily, be considered as justifying the amount of labor involved in their examination."

It will be noted that in these "directions" the depth of the surface "soil" sample to be taken is left to the judgment of the farmer, between the limits of 6 and 12 inches; the first being the minimum, the latter the maximum depth to which rational culture usually reaches.

When the soil sample is to be transmitted to any considerable distance, it is very desirable that it should be dried as completely as possible before shipment; since otherwise not only does it often arrive in an abnormally puddled and compacted condition, but may become moldy, changing the natural condition not only of the organic, but also of the reducible inorganic ingredients; notably that of ferric hydrate, and nitrates. With respect to the latter, the date of taking the sample is also desirable, and should be recorded in every case.

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METHOD OF CHEMICAL SOIL ANALYSIS.

The methods of chemical soil analysis hereinafter given are essentially those which, in their main features, have been pursued by Drs. David Dale Owen and Robert Peter, in the work of the geological surveys of Kentucky and Arkansas, and which have since been further developed by the writer in the soil work of the surveys of Mississippi and Louisiana; in that done in connection with the tenth census "Report on Cotton Culture" throughout the Cotton States; in that of the Transcontinental Survey, in the States of Oregon, Washington, and Montana; and in the soil work of the California Experiment Station. Altogether these methods of soil investigation have been applied to over a thousand virgin soils, the analyses of which are strictly comparable among themselves; therefore by far the largest uniform set in existence thus far. Considering the labor involved in the work so performed, it becomes a serious question whether there are any valid reasons why the methods employed in it should be changed in any essential points; since to do so might throw out of any possible comparison with future work, the bulk of what has heretofore been done in soil investigation on the North American continent. Their convenience and substantial accuracy within the limits of personal error have been tested by considerable experience, and the mode of interpreting the analytical results so as to accord with the farmers' experience in cultivation has been developed with respect to analyses made in accordance therewith.

It should be understood that these methods contemplate an approximation to the *maximum of solvent effect* plants can exert upon the soil; carbonated water being by far too feeble as a solvent to represent even ordinary plant action, while hydrofluoric acid goes far beyond vegetative possibilities.

Preliminary Preparation of the Sample.—The soil is thoroughly broken up dry with a rubber pestle, or in the case of clayey soils is digested with distilled water until fully disintegrated. A weighed quantity (200 to 500 grams) is then sifted or washed, as the case may be, through a sieve of 0.5 mm. clear aperture; if washed, the muddy water must be evaporated to dryness with the soil slush and the whole thoroughly mixed. The sample so obtained constitutes the "fine earth" to be used in chemical analysis; the coarse portions are to be further segregated by sieves, weighed, and their mineralogical constituents identified with the microscope, reagents, or Thoulet's solution, as the case may require. That the introduction of the grain-sizes coarser than 0.5 mm. can, as a rule, serve no useful purpose in the chemical analysis, is strikingly shown in the investigation made by R. H. Loughridge, in 1873 (Am. J. Sci., Jan., 1874, p. 17). He found that in the case of a very generalized soil of the Mississippi uplands, solution by strong acid practically ceased beyond the sediment of 0.5 mm. hydraulic value, corresponding to a diameter of about 0.025 mm. Although the *general* applicability of this particular limit may be fairly questioned, the wide margins between the fractions 0.5 and 0.025 renders it pretty certain that within the limit of the former we shall find *all* that is of any value to plants for their supply of mineral plant food. But for the sake of comparability with analyses made under a different rule, the grain sizes of 1 and 2 mm. diameter should always be quantitatively determined.

Determination of the Hygroscopic Coefficient.—The fine earth is exposed to an atmosphere saturated with moisture for about twelve hours at the ordinary temperature (60° F.) of the cellar in which the box should be kept. For this it is sifted in a layer of about 1 mm. thickness upon glazed paper, on a wooden table in a small covered box (12x9x8 inches), in which there is about an inch of water; the interior sides and cover of the box should be lined with blotting paper, kept saturated with water, to insure the saturation of the air.

["Air-dried soil" yields results varying from day to day, to the extent of as much as 30 to 50 per cent, nor have we any corrective formula that would reduce such observations to absolute measure. Knop's law (that the absorption varies directly as the temperature), while applicable to low percentages of saturation, is wide of the truth when saturation is approached. My observation has shown that between the temperature of 7° and 23° C., the coefficient of absorption in saturated air varies only by a small fraction; hence the ordinary temperature of cellars will serve well in these determinations, without material correction.]

After eight to twelve hours the earth is transferred as quickly as possible, in the cellar, to a weighed drying tube and weighed; it is then placed in a paraffine bath, the temperature gradually raised to 200° C., and kept there twenty to thirty minutes (rapidity of raising temperature depending upon the amount of moisture in the soil), a current of dry air passing continually through the tube. It is then weighed again, and the loss in weight gives *hygroscopic moisture* in saturated air.

[The reason for adopting 200° C. as the temperature for drying, instead of 100°, is that water will continue to come off from clayey soils at the latter temperature for an indefinite time—a week or more—before an approach to constancy of weight is attained; and that up to 200° only an arbitrary limit can be assigned for the expulsion of "hygroscopic moisture." Moreover, the great majority of soils (viz., those poor in humus) will reabsorb moisture from a saturated atmosphere to the full extent of that driven off at 200° C. These observations, originally made by Dr. David Dale Owen, I have since repeatedly verified.]

GENERAL ANALYSIS.

The samples for general analysis and phosphoric acid determination are weighed out directly from the drying tube.

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In determining the amount of material to be employed for the general analysis, regard must be had to the nature of the soil. This is necessary because of the impracticability of handling successfully such large precipitates of alumina as would result from the employment of as much as 5 grams in the case of calcareous clay soils; while in the case of very sandy soils, even that quantity might require to be doubled in order to obtain weighable amounts of certain ingredients. For average loam soils in which the soluble portion ranges from 60 to 80 per cent, 2.5 to 3 grams is about the right measure for general analysis, while for the phosphoric acid determination not less than 3 grams should be employed in any case.

[It has been alleged that larger quantities must be taken for analysis in order to secure average results. It is difficult to see why this should be true for soils and not for ores, in which the results affect directly the money value, while in the case of soils the interpretation of results allows much wider limits in the percentages. Correct sampling must be presupposed to make *any* analysis useful; but with modern balances and methods, it is difficult to see why 5 grams should be employed instead of half that amount, which in some cases is still too much for convenient manipulation of certain precipitates.]

1. The weighed quantity, usually of 2 to 2.5 grams, is brought into a small porcelain beaker covered with a watch glass, treated with eight to ten times its bulk of hydrochloric acid of 1.115 sp. gr., and two or three drops of nitric acid, and digested for five days over the laboratory steam bath. At the end of this time it is evaporated to dryness, first on the water bath and then on the sand bath. By this treatment all the silica set free is rendered insoluble.

[In an investigation made by Loughridge in 1873 (Am. J. Sci., Jan., 1874, p. 20), it was found that acid of the above strength exerted a higher solvent power than that materially stronger or weaker (1.100 or 1.160 sp. gr.). The above standard strength is easily prepared by steam distillation of acid either stronger or weaker. He also found that after the *fifth* day no further essential solvent action occurred. Later investigations by Jaffa show that the effect of such acid approximates closely to that of oxalic acid, the strongest solvent available for plant-root action. *We therefore determine in such treatment the maximum effect vegetation can exert on soils.*]

The dry residue is moistened with strong hydrochloric acid and two or three drops of nitric acid, warmed, and after allowing it to stand a few hours on the water bath, treated with distilled water. After clearing, it is filtered from the insoluble residue, which is strongly ignited and weighed.

[If the filtrate should be turbid, the insoluble residue which has gone through the filter can be recovered in the iron and alumina determination.]

The insoluble residue is next boiled for fifteen or twenty minutes in a concentrated solution of carbonate of soda, to which a few drops of caustic lye should then be added to prevent re-precipitation of the dissolved silica. The solution must be filtered hot.

The difference between the weight of the total residue and that of undissolved sand and mineral powder is recorded as "soluble silica," being the aggregate of that set free by the acid treatment, and of that previously existing in the soil. The latter, however, rarely reaches 0.5 per cent.

2. The acid filtrate from the total insoluble residue is evaporated to a convenient bulk. In case the filtrate should indicate by its color the presence of any organic matter, it should be oxidized by aqua regia, otherwise there will be difficulty in separating alumina.

3. The filtrate thus prepared is now brought to boiling and treated sparingly with ammonia, *whereby iron and alumina* are precipitated; it is kept boiling until the excess of ammonia is driven off, and then filtered hot. (Filtrate A.) The previous addition of ammonic chloride is usually unnecessary.

[If the boiling is continued *too long*, filtration becomes very difficult, and a part of the precipitate may redissolve in washing. Filtration may be begun so soon as the nose fails to note the presence of free ammonia; test paper is too delicate. Failure to boil *long enough* involves the contamination of the iron-alumina precipitate with lime and manganese.]

4. The iron and alumina precipitate (with filter) of No. 3 is dissolved in a mixture of about 5 cc. hydrochloric acid and 20 cc. water. Then filter and make up to 150 cc. Take 50 cc. for the determination of iron and alumina together by precipitation with ammonia, after oxidizing the organic matter (filter) with aqua regia; also 50 cc. for iron alone; keep 50 cc. in reserve. Determine the iron by means of a standard solution of permanganate of potash, after reduction; this latter is done by evaporating the 50 cc. almost to dryness with strong sulphuric acid, adding water and transferring the solution to a flask and then reducing by means of pure metallic zinc in the usual way. The alumina is then determined by difference.

[This method of determining the two oxides in their intermixture is, in several respects, more satisfactory than the separation with alkaline lye, which, however, has served for most determinations made until within the last ten years. The latter is much more liable to miscarry in unpracticed hands than the other.]

5. The filtrate A from iron and alumina is acidified slightly with hydrochloric acid, and, if too bulky, is evaporated down to about 25 ccm. (unless the soil is a very calcareous one), and the *lime* is precipitated from it by neutralizing with ammonia and adding ammonic oxalate. The precipitation of the lime should be done in the hot solution, as the precipitate settles much more easily. It is allowed to stand for twelve hours, then filtered off, washed with cold water, and dried. (Filtrate C.)

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By ignition the lime precipitate is partially converted into the oxide. It is then heated with excess of powdered ammonium carbonate, moistened with water, and exposed to a gentle heat (50° to 80° C.), until all the ammonia is expelled. It is then dried below red heat, and weighed as lime carbonate. When the amount of lime is at all considerable, the treatment with ammonic carbonate must be repeated till a constant weight is obtained.

6. The filtrate C, from the calcic oxalate, is put into a hard bohemian flask, boiled down over the sand bath, and the ammoniacal salts destroyed with aqua regia (Lawrence Smith's method). From the flask it is removed to a small beaker and evaporated to dryness with excess of nitric acid. This process usually occupies four to five hours. The residue should be crystalline-granular; if white-opaque, ammonic nitrate remains, and must be destroyed by hydrochloric acid.

The dry residue is now moistened with nitric acid, and the floccules of silica usually present separated by filtration from the filtrate, which should not amount to more than 10 or 15 ccm. Sulphuric acid is then precipitated by treatment with a few drops of baric nitrate; both the solution and the reagent being heated to boiling. If the quantity of sulphuric acid is large, it may be filtered off after the lapse of four or five hours (Filtrate D). If very small, let it stand twelve hours. The precipitate is washed out with boiling water, dried, ignited, and weighed. (Filtrate D.)

[Care should be taken in adding the barium nitrate to use only the least possible excess, because, in such a small concentrated (acid) solution, the excess of barium nitrate may crystallize and will not readily dissolve in hot water. Care must also be taken not to leave in the beaker the large heavy crystals of baric sulphate, of which a few sometimes constitute the entire precipitate, rarely exceeding a few milligrams. Should the ignited precipitate show an alkaline reaction on moistening with water, it must be treated with a drop of hydrochloric acid re-filtered and re-weighed. The use of barium acetate involves unnecessary trouble in this determination.]

7. Filtrate D is now evaporated to dryness in a platinum dish; the residue is treated with an excess of crystallized (preferably sublimed) oxalic acid, moistened with water, and exposed to gentle heat. It is then strongly ignited to change the oxalates to carbonates. This treatment with oxalic acid must be made in a vessel which can be kept well covered, otherwise there is danger of loss through spattering. As little water as possible should be used, as otherwise loss from evolution of carbonic gas is difficult to avoid. Spatters on the cover should not be washed back into the basin until after the excess of oxalic acid has been volatilized. The ignited mass should have a slightly blackish tinge, to prove the conversion of the nitrates into carbonates. White portions may be locally retreated with oxalic acid. The ignited mass is treated with a small amount of water, which dissolves the alkaline carbonates, and leaves the carbonates of magnesia, proto-sesquioxide of manganese, and the excess of barium carbonate behind. The alkalies are separated by filtration into a small platinum dish (Filtrate E), and the residue well, but economically, washed with water on a small filter. When the filtrate exceeds 10 cc., it may, on evaporation, show so much turbidity from dissolved earthy carbonates as to render refiltration on a minute filter necessary, since otherwise the soda percentage will be found too large, magnesia too small.

[If, on dissolving the ignited mass, the solution should appear greenish from the formation of alkaline manganates, add a few drops of alcohol to reduce the manganese to insoluble dioxide.]

The residue of barium, magnesium, and manganese compounds is treated on the filter with the hydrochloric acid, and the platinum dish is washed with warm nitric acid (not hydrochloric, for the platinum dish may be attacked by chlorine from the manganese oxide), dissolving any small traces of precipitate that may have been left behind.

8. The solution containing the chlorides of magnesium and manganese is freed from the barium salts by hot precipitation with sulphuric acid, and the barium sulphate, after settling a few hours, is filtered off. The filtrate is neutralized with ammonia, any resulting small precipitate (of iron) is filtered off, and the manganese precipitated with ammonic sulphide. Let stand twelve hours and filter (Filtrate F); wash with cold water, dry, ignite, and weigh as manganese proto-sesquioxide (Mn_3O_4).

[If preferred, the manganese may be precipitated with chlorine or bromine water as dioxide; but the process requires a rather longer time and may fail in inexpert hands more readily than the others.]

9. The filtrate F from the manganese is now freed from sulphur by acidulating with hydrochloric acid, evaporating down, if necessary, and filtering. From the filtrate the *magnesia* is precipitated by adding an equal bulk of ammonia water and then sodic phosphate. After standing *at least* twenty-four hours, the magnesia salt may be filtered off, washed out with ammoniacal water, dried, ignited, and weighed as magnesium pyrophosphate.

10. The filtrate E (which should not be more than 10 or 15 ccm.), containing the carbonates of the *alkalies*, is evaporated to dryness and gently fused, so as to render insoluble any magnesium carbonate that may have gone through; then redissolved and filtered into a small weighed platinum dish containing a few drops of hydrochloric acid, to change the carbonates into chlorides; evaporated to dryness, exposed to a gradually rising temperature (below red heat), by which the chlorides are thoroughly dried and freed from moisture, so as to prevent the decrepitation that would otherwise occur on ignition. Then, holding the platinum basin firmly by forceps grasping the clean edge, pass it carefully over a very low Bunsen flame, so as to cause, successively, every portion of the

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scaly or powdery residue to collapse without fully fusing. There is thus no loss from volatilization, and no difficulty in obtaining an accurate, constant weight.

The weighed chlorides are washed by means of a little water into a small beaker or porcelain dish, treated with a sufficient quantity of platinic chloride, and evaporated to dryness over the water bath. The dried residue is treated with a mixture of three parts absolute alcohol and one part ether, leaving the potassio-platinic-chloride undissolved. This is put on a filter and washed with ether-alcohol. When dried, the precipitate and filter are put into a small platinum crucible and exposed to a heat sufficiently intense to reduce the platinum chloride to metallic platinum and to volatilize the greater part of the potassium chloride. This is easily accomplished in a small crucible, which is roughened by being constantly used for the same purpose (and no other), the spongy metal causing a ready evolution of the gases. (See Fresen. Zeitschr f. analyt. Chemie, 1883.)

The reduced platinum is now first washed in the crucible with hot acidulated water, then with pure water; then all moisture is driven off and it is weighed. From the weight of the platinum is calculated the *potassic chloride* and the oxide corresponding; the difference between the weights of the total alkaline chlorides and potassic chloride gives the sodic chloride, from which may be calculated the sodic oxide.

[When the heating of the platinum precipitate has not been sufficient in time or intensity, instead of being in a solid spongy mass of the color of the crucible itself, small black particles of metallic platinum will obstinately float on the surface of the water in the crucible, and it becomes difficult to wash without loss.]

PHOSPHORIC ACID DETERMINATION.

11. The weighed quantity (usually of 3 to 5 grams) is ignited in a platinum crucible, care being taken to avoid all loss by dusting. The loss of weight after full ignition gives the amount of chemically combined water and volatile and combustible matter.

12. The ignited soil is now removed to a porcelain or glass beaker, treated with four to five times its bulk of strong nitric acid, digested for two days, evaporated to dryness first over the water bath and then over the sand bath, moistened with nitric acid, heated, and treated with water. After standing a few hours on the water bath, it is filtered off from the insoluble residue and the filtrate is evaporated to a very small bulk (10 cc.), and treated with about twice its bulk of the usual ammonium-molybdate solution, thus precipitating the phosphoric acid. After standing at least twelve hours, at first at a temperature of about 50° C., it is filtered off and washed with a solution of ammonium nitrate acidified with nitric acid. The washed precipitate is dissolved on the filter with dilute ammonia water. After washing the filter carefully, the ammoniacal solution is treated with magnesia mixture, by which the phosphoric acid is precipitated. After allowing it to stand twenty-four hours, it is filtered off, washed in the usual way, dried, ignited, and weighed as magnesium pyrophosphate, from which the phosphoric acid is calculated. The per cent of phosphoric acid found is to be subtracted from that of the alumina.

[When a gelatinous residue remains on the filter after dissolving the molybdo-phosphate with ammonia, it may consist either of silica not rendered fully insoluble in the first evaporation, or, more rarely, of alumina containing phosphate. It should be treated with strong nitric acid, and the filtrate with ammonic molybdate; any precipitate formed is of course added to the main quantity before precipitating with magnesia solution.]

HUMUS-DETERMINATION IN SOILS.

(*Grandeau's Method.*)

About 10 grams of soil is weighed off into a prepared filter. The soil should be covered with a piece of paper (a filter), so as to prevent it from packing when solvents are poured on it.

It is now treated with hydrochloric acid, from 0.5 to 1 per cent strong (25 cc. of strong acid and 808 cc. of water), to dissolve out the lime and magnesia, which prevent the humus from dissolving in ammonia. Treat with the acid until there is no reaction for lime; then wash out the acid with water, to neutral reaction.

Dissolve the humus with weak ammonia water (about 4 per cent), prepared by diluting common ammonia water (178 cc. ammonia to 422 cc. water).

Evaporate the humus solution to dryness in a weighed platinum dish, at 100° C.; weigh, then ignite; the loss of weight gives the weight of humus (*matiere noire*).

The residue from ignition is carbonated with carbonic gas, heated and weighed; thus giving the ash. It is then moistened with nitric acid, and evaporated to dryness. The residue is treated with nitric acid and water, allowed to stand a few hours, and the solution filtered from the insoluble residue, which is ignited and weighed; giving the *silica*.

The "soluble" phosphoric acid is determined from the solution by the usual method, as magnesic pyrophosphate. It usually amounts to a fraction varying from one half to as little as one tenth of the total in the soil.

While the P_2O_5 so determined is manifestly more soluble, and more available to vegetation than the rest of that found by extraction with stronger acid, it is clearly not as available as that which, when introduced in the form of superphosphates, exerts such striking effects, even though forming a much smaller percentage of the whole soil. Nevertheless, a very striking agreement with actual practice is often found in making this determination.

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[The estimation of "humus" by combustion, in *any* form, of the *total* organic matter in the soil, gives results varying according to the season, and having no direct relation to the active humus of the soil. The same objection lies against extraction with strong caustic lye.]

Determination of Nitrogen in Soils.—The humus-determination will, in the case of virgin soils, usually indicate approximately the store of nitrogen in the soil, which must be gradually made available by nitrification. Ordinarily (outside of the arid regions) the determination of ammonia and nitrates present in the soil is of little interest for *general* purposes, since these factors will vary with the season, and from day to day.

The usual estimate of nitrogen in black soil humus (Grandeau's *matiere noire*, determined as above) is from 3 to 6 per cent in the regions of summer rains. From late determinations it would seem that in the arid regions, the usually small amount of humus (often less than 0.20 per cent) is materially compensated by a higher nitrogen percentage. It thus becomes necessary to determine the humus nitrogen directly; and this is easily done by substituting in the Grandeau process of humus extraction, potash or soda lye for ammonia water, and determining the nitrogen by the Kjeldal method in the filtrate. While it is possible that the ammonia water would not vitiate the determination of nitrogen in the case of neutral or calcareous soils, it would certainly do so in the case of those having an acid reaction.

The lye used should have the strength of 4 per cent in the case of potassic hydrate; 3 per cent in that of sodic hydrate. The black humus-filtrate is carefully neutralized with sulphuric acid, evaporated to small bulk in a beaker or evaporating basin, and the reduced liquid finally evaporated to dryness in the Kjeldal flask itself, by means of a current of air. The beaker or basin is washed either with some of the alkaline lye, or after evaporation, with warm concentrated sulphuric acid, which is then used in the nitrogen determination in the usual way.

For the determination of *nitrates* in the soil, it is, of course, usually necessary to use large amounts of material, say not less than 100 grams, and according to circumstances, five or more times that amount. In the evaporated solution, the nitric acid is best determined by the reduction method, as ammonia.

Usually the soil filtrate is clear and contains no appreciable amount of organic matter that would interfere with the determination; yet in the case of alkaline soils (impregnated with carbonate of soda) a very dark-colored solution may be obtained. In that case the soil may advantageously be mixed with a few per cent of powdered gypsum before leaching; or the gypsum may be used in the filtrate to discolor it by the decomposition of sodic carbonate and the precipitation of calcic humate. The evaporated filtrate can then be used for the nitrate determination by either the Kjeldal, Griess, or "Nesslerizing" process, which will, of course, include such portions of the ammoniacal salts as may have been leached out.

For the separate determination of these and of the occluded ammonia, when desired, it is probably best to mix the wetted soil intimately with about 10 per cent of magnesic oxide and distill off into titrated chlorhydric acid. For *general* purposes, however, this determination is usually of little interest.

[Kedzie, in the report above quoted, proposes to estimate the active soil nitrogen (ammonia plus nitrates and nitrites) by treatment of the whole soil with sodium amalgam, and distillation with lime. The objection to this process is, that the formation of ammonia by the reaction of the alkali and lime upon the humus amides would greatly exaggerate the active nitrogen and lead to a serious over-estimate of the soil's immediate resources.]

It is strenuously suggested that in the *presentation* of the results of a soil analysis, the order of the electrolytic series be observed, as in the schedule annexed; so as to facilitate comparisons. The "insoluble residue" is best placed at the head of the column, as it indicates at a glance, approximately, the general character of the soil, as sandy or clayey.

For suggestions concerning the interpretation of analyses made according to the above methods, see "Report on the Experiment Stations of the University of California," 1890, pages 151 to 172.

Coarse materials >0.5^{mm} diameter		
Fine earth		

Analysis of Fine Earth.

Insoluble matter		
Soluble silica		
Potash (K_2O)		
Soda (Na_2O)		
Lime (CaO)		
Magnesia (MgO)		
Br. ox. of manganese (Mn_3O_4)		
Peroxide of iron (Fe_2O_3)		
Alumina (Al_2O_3)		
Phosphoric acid (P_2O_5)		
Sulphuric acid (SO_3)		
Carbonic acid (CO_2)		
Water and organic matter		
Total		

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Humus	------	------
Ash	------	------
Sol. phosphoric acid	------	------
Silica	------	------
Nitrogen (organic)	------	------
Hygroscopic moisture (absorbed at —° C.)	------	------
	Volume.	Weight.
Water capacity .. {Maximum	------	------
Water capacity .. {Minimum	------	------

THE METHOD OF MECHANICAL SOIL ANALYSIS.

The "insoluble residue" of the chemical analysis indicates, in a very general manner, the amount of "sand" in a soil; and, when combined with a determination of the soluble silica, alumina, and lime, we also gain some idea of possible plasticity or "heaviness." But these indications given by chemical analysis are far too indefinite for practical requirements. It is to the mechanical (or physical) analysis that we must look for practically available data on the tilling quality of soils; but the loose practice prevailing thus far has rendered the results far from satisfactory.

As regards, first, the conventional "clay," which figures in the analytical statements, *e. g.*, of the German investigators, it oftentimes consists far more of fine silex than even of *total* kaolinite substance. Since the latter itself consists at least of two portions totally distinct in their physical functions, viz.: of chalky crystalloid grains, and of a colloidal, highly diffusible, and extremely adhesive and hygroscopic portion, the presence of which determines, in the main, the corresponding physical properties of the soil: the indefiniteness of the current mode of statement, and consequent classification of soils, is so great as to render a clearer and more rational and definite method of mechanical analysis absolutely necessary, from this point of view alone. An additional source of error arises from the viscosity, and consequent greater hydraulic efficacy, of "clay water," which carries off, at the same velocity, much larger particles of rock powder than does pure water; or, in case of subsidence, permits them to settle much more slowly. The consequence is that the percentage of a sediment of a given "hydraulic value" will be found very different, according to the amount of colloidal clay present, or according as the latter has or has not been, wholly or partially, removed prior to the separation of the simply pulverulent or sandy ingredients. Adding to these sources of uncertainty the wide range of size of grain included and weighed as one sediment by most observers, the slight value attaching thus far to the results of mechanical soil analysis, as representing the farmer's experience, is amply explained.

Sedimentation and Hydraulic Elutriation.—For the separation of fine powders of mixed grain-sizes, sedimentation by stirring up in water and drawing off the suspended sediment with the water after a definite time allowed for the subsidence of the coarser portions, is, of course, the simplest process, which has been used in the arts and in pharmacy for centuries. For analytical purposes it has the disadvantage that, in order to effect a reasonably complete exhaustion of a sediment of a definite size or "hydraulic value," the operation of stirring-up and drawing-off must be repeated a large number of times; since the time of subsidence is reckoned for the top layer of water, while subsidence actually occurs from below as well. The subsidence method requires close and continuous attention in its execution, for a length of time proportioned to the minuteness of subdivisions desired; moreover, in the case of fine sediments which have a tendency to coalesce (flocculate) under the action of irregular currents caused by stirring, the difficulty of obtaining them properly segregated is almost insuperable, greatly detracting from the accuracy of the determinations. The subsidence or (as it has lately been termed) "beaker" method, however convenient on account of its simplicity, is therefore ill adapted to the carrying out of extended investigations requiring the performance of a large number of mechanical soil analyses; and its laboriousness has long caused it to be replaced, in European practice, by various devices embodying, in a more or less perfect form, the idea of separation of grain-sizes by an ascending current of water, or "hydraulic elutriation."

Preliminary Examination.—The first step toward the determination of the character of a soil sample should always be what might be termed the hand tests; to wit, the observation of the greater or less degree of ease with which the soil lumps crush between the fingers in the dry condition; the presence or absence of coarse sand, etc.; also the change of color on wetting, the degree of rapidity with which the water is absorbed, the extent to which it softens the lumps, and the degree of plasticity assumed when the wet soil is kneaded.

The next step should be the at least approximate identification of the minerals forming the coarse portion, since it must be presumed that, as a rule, these represent the nature of the fine grains also. We thus gain already a very close insight into the origin and general character of the soil.

This mineralogical examination is advantageously combined with an approximate quantitative determination of the coarse portion, by sedimentation in a small beaker, or more advantageously, by means of "Kühn's cylinder" and an upward current of water of definite velocity; that of 2 mm. per second is convenient for this purpose, provided that the sample is kept stirred by means of a rod. The dried coarse portion is weighed and then examined with a lens and microscope, with or without previous separation by

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means of Thoulet's or some other dense fluid. This examination is of especial value in the identification of the sample with other soils previously investigated, and thus frequently saves a very large amount of analytical labor.

Detailed Mechanical Analysis.—When the preliminary examination does not suffice for the purposes in view and detailed mechanical or "silt analysis" must be resorted to, more elaborate and complex methods and appliances are called for.

[When in 1872 I began the consideration of this subject in connection with the agricultural survey of the State of Mississippi, even a very superficial test led me to reject quickly the grossly inaccurate and misleading apparatus of Nöbel, with its four vessels of ever varying capacity and form, and inconstant head of water. The best then known, that of Schöne, proved much more satisfactory; *provided the "colloidal clay" was first removed.* But even then there remained a large and variable residual error, shown in the mixed grain-sizes of the sediments, and correspondingly varying percentage results. A protracted investigation of the causes of these inaccuracies, made in the years 1872 and 1873, and published in the latter year,* proved that the great difficulty encountered in the separation of soil ingredients by the ordinary methods of sedimentation heretofore employed has been the strong tendency of the fine particles to coalesce, and come off with the coarser sediments. When violently shaken, they part company, and become diffused, singly, through the liquid, which then presents simply a general turbidity; the particles then settling down slowly and singly, at the rate corresponding to their individual size or hydraulic value.

The following experiment, well suited to the lecture table, serves to demonstrate the above principle: If a given quantity of pure siliceous sediment of *e. g.*, 1 mm. hydraulic value (which has therefore been carried off at the velocity of 1 mm. by an ascending current of water) be again placed in the same current in a long conical tube with cylindrical outlet above, a considerable portion will fail to pass off, and will gather into flocculent aggregates revolving in the lower (narrow) part of the tube. If instead of the full velocity of 1 mm. only 0.8 mm. is used, *none* of the sediment will pass off, but after some time it will be found wholly gathered together into the heavy flocculent aggregates; when the full velocity of 1 mm. may be used without causing any considerable portion of sediment to be carried off, until by violent stirring with a *rod* the flocculles are destroyed. It is only, however, by repeating this outside stirring a number of times that it is possible to get nearly all the sediment corresponding to the velocity of current actually used to pass off. *The stirring by the current itself is powerless to do so, because the return-currents down the sides of a conical tube perpetually cause re-coalescence, or "flocculation."*

It is thus clearly established that even with purely siliceous and non-glutinous sediments, correct results cannot be obtained so long as *conical* elutriator-tubes are employed; and this disposes effectually of the claims of *e. g.* Schöne's apparatus (now adopted by the German Experiment Stations) to anything like the accuracy required in this work.

But if cylindrical elutriator-tubes are alone admissible, then it follows that *agitation by outside power*, for keeping the soil or powder in suspension and continuously resolving the flocculles inevitably formed under the circumstances, is indispensable. However, the tendency to coalescence diminishes, of course, as the size of the grains increases; but does not altogether cease until their diameter exceeds 0.2 mm., or about 16 mm. hydraulic value. For the elutriation of coarser sediments, hydraulic stirring may be successfully employed.]

We may therefore formulate as follows the conditions to be fulfilled by mechanical soil analysis upon which definite conclusions as to the physical and agricultural (or "working") qualities of soils, and of the functions of the several grain-sizes in determining the same, may be based:

1. The preliminary preparation of the soil sample must leave its natural condition unimpaired. It must therefore not be heated to any temperature likely to wholly or partially dehydrate any of its constituent colloids; nor must it be triturated or "pestled" in any manner likely to destroy the naturally existing aggregates or flocculles cemented by lime carbonate, ferruginous, zeolitic, or other cements. *Boiling* is free from these objections.

2. Prior to any attempt to separate the different grain-sizes, whether by the hydraulic or subsidence method, all the "*colloidal clay*" must be completely removed; and in view of the prime importance of the latter as a physical soil-ingredient, it must be determined by *direct weighing* and not merely by loss, resp. "difference."

3. If the hydraulic method be used for the separation of the successive grain-sizes, this must be done in vertical, *cylindrical* elutriator-tubes provided with a device for mechanical stirring by outside power, for preventing and undoing the flocculation of the sediments into heavy aggregates of indefinite composition and hydraulic value.

4. The importance of discriminating between the several fine sediments in respect to their physical functions, is so great that a *much larger number of subdivisions* of these must be made than is now usually done. This proviso renders the ordinary process of sedimentation by stirring and subsidence in cylindrical vessels ("beaker method") practically inapplicable to any extended investigations requiring frequent and numerous mechanical analyses; since each one would take an amount of time and practice quite out of reach of ordinary laboratory *personnel.* The work must in the main be done automatically, to be generally available.

*Amer. Jour. of Sci., Oct., 1873; Proc. Am. Assn. Adv. Sci., Portland meeting, 1873. See also, "The Flocculation of Particles," Am. J. Sci., March, 1879.

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The ways and means by which these several conditions may most easily be fulfilled will now be considered in detail.

Preliminary Preparation.—In some cases, simple sifting will serve, without further preparation, to separate the original, dry soil sample into appropriate subdivisions, down to the "fine-earth" that is to serve for detailed mechanical and chemical analysis. In most cases, however, a certain amount of mechanical disintegration must be resorted to in order to detach the earth from the larger sand-grains and aggregates; and here some judgment must be exercised by the operator. A preliminary washing, aided by the lens and microscope, if necessary, will show whether there are any soft concretions or decomposed rock particles likely to be crushed by a rubber pestle—the hardest material admissible, but which will serve admirably when no soft grains will be crushed by it, thus changing the nature of the soil to a corresponding extent. The liability to such change is much increased by wetting the soil, when calcareous and ferruginous concretions (bog ore) may be crushed to such extent as to destroy the value of the work. In the case of heavy clay ("adobe") soils, however, wetting, and even hot digestion with water, may be necessary to even the preliminary disintegration, serving to prepare a fair average sample. The slushy mass must then be economically washed through the fine-earth sieve, and the remnant afterwards separated into sizes by sifting, while the fine-earth slush is evaporated and dried, to serve for analysis.

Since a sieve of 0.5 mm. aperture is practically about the finest that will serve for the dry separation with advantage, and since that same diameter is almost exactly that of quartz-grains passing off at the maximum current-velocity conveniently available, viz.: 64 mm. per second, I have adopted the 0.5 mm. limit as practically the best for the fine-earth to be used for both mechanical and chemical analysis. It is to such "fine-earth" that the data hereinafter given are meant to apply.

Disintegration by Boiling.—This is applicable to all soils, the time required varying greatly with different ones; those containing much lime carbonate require the longest time to resolve those aggregates which will be also destroyed by tillage. Further than this the disintegration should not go, nor should it fall seriously short of that normal measure. Thirty hours have in one case barely sufficed for a black calcareous "prairie" soil, while three have been found sufficient to reduce other soils to clean, single grains, as observed under the lens. While an absolute rule cannot therefore be given, it may be said that with most soils from eight to fifteen hours will be the right measure, which with some may extend to twenty and twenty-four. The fact ascertained by Osborne, that the diffusibility of some clays, at least, is diminished by long boiling, renders it desirable to restrict its duration to a minimum.

The boiling is best done in a thin, long-necked flask of about one liter capacity, filled four fifths full of distilled water, and laid on a stand, on wire netting, at an angle of 40° to 45°. It is provided with a cork and condensing tube of sufficient length (5 to 6 feet) to condense all or most of the steam formed when ebullition is kept up by means of a gas flame. For a few hours the boiling generally proceeds quietly; but as the disintegration progresses, violent bumping sets in, which sometimes endangers the flask, but is of assistance for the attainment of the object in view. In extreme cases some of the heavier sediment (generally clean sand) may be removed from the flask, but this is undesirable.

It is frequently the case that when the boiled contents are left to settle, the liquid appears perfectly clear within an hour, although so soon as they are largely diluted the clay becomes diffused as usual, and will not settle in weeks. Probably this is owing to the extraction from the soil of soluble salts, which exert the same influence as does lime or common salt, even in very dilute solutions.

Removal of the Colloidal Clay and Finest Sediments.—The boiled fluid and sediment are transferred to a beaker, and diluted so as to form from one to one and one half liters in bulk; and being stirred up, is allowed to settle for such a length of time as (taking into account the height of the column) will allow all sediments of 0.25 mm. hydraulic value to subside; the process being repeated with smaller quantities of water (distilled), until no sensible turbidity remains after allowing due time for subsidence.

It must be remembered that this time is considerably longer than that for pure water, *so long as any considerable amount of clay remains in the liquid*, rendering it more viscous. And as the precise amount of allowance to be made cannot in general be foreseen, some sediment of and exceeding 0.25 mm. hydraulic value will almost inevitably be decanted with the successive clay waters, until the buoyant effect of the clay becomes insensible. The united clay waters (of which there will be from 4 to 8 liters) must therefore be again stirred up, and the proper time allowed for the sediments of 0.25 mm. and over to subside. The dilution being very great, a pretty accurate separation is thus accomplished; the sediments being then ready for the elutriator.

Separation of Clay and the Finest Silt in the "Clay Water."—The now well-known property of colloidal clay, of remaining suspended in the pure water for weeks and even months, offers an obvious method of separation from at least the greater portion of silts finer than 0.25 mm. hydraulic value (<0.25). To push this separation to the extreme of attempting to remove *all* but the kaolinite particles proper, even were it feasible, would carry the time and labor required for the determination beyond the limits required for practical purposes, and would render the performance of mechanical analyses rare events in most laboratories. In special cases, of course, it may be desirable to go to these lengths, and also to divide the sediments lying between the clay proper and the finest sediment that can conveniently be obtained by the hydraulic method (0.25 mm. h. v.) into two or more groups, when it is very abundant.

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I place the clay water for subsidence in a wide cylindrical vessel (in which it may conveniently occupy 200 mm. in height); it is there allowed to settle for twenty-four hours. This interval of time was at first arbitrarily chosen; but I subsequently found it to be about the average time required by the finest siliceous silt usually present in soils, to sink through 200 mm. of pure water. So long as any sensible amount of clay is present, the time, of course, is longer, say from forty to sixty hours, or even more, if the clay be abundant, and the liquid not very dilute. The sharp line of separation between the dark silt-cloud below and the translucent clay water above is readily observed, and the time of subsidence regulated accordingly. At times, several such lines of division may be seen simultaneously in the column, indicating silts of successive sizes, with a break between. No such appearance is presented when, after weeks of quiet, the clay itself gradually settles. The liquid, which may be almost clear at the surface, then shades off downward very gradually, until, near the bottom of the vessel, it becomes entirely opaque.

After decantation of the clay water, the remaining liquid is poured off temporarily, leaving the sediment as dry as possible. It is then rubbed or kneaded in the decanting vessel itself, with a long-handled, soft rubber pestle (conveniently cut out of a rubber "cork"). At this point the addition of a few drops of ammonia water, according to Schlösing's prescription, renders good service; but it is undesirable to use any large amount of ammonia, as it impedes the subsequent precipitation of the colloidal clay.

Distilled water is again poured on (agitating as much as possible, to break up the molecular aggregates) to the proper height, and another twenty-four hours' subsidence allowed. This operation is repeated (six to nine times), until either the water remains almost clear after the last subsidence, or the decanted turbid water fails to be precipitated by salt water, showing the suspended matter to be pulverulent silt only.

Doubtless the fine silt obtained in the twenty-four hours' subsidence, the diameter of whose quartz particles varies from 0.001 to 0.02 of a millimeter, is not entirely free from adherent colloidal clay, as is indicated by its deeper tint, compared with that of the coarser sediments. The extent to which this contamination exists, and the distribution of the important soil ingredients among the several sediments, have been discussed in other papers.

Determination of the Colloidal Clay.—The colloidal portion of the kaolinite constituent is of such preëminent importance that to throw upon it the indefinite "loss by analysis," and estimate it "by difference," is hardly excusable. Two ways of determining it directly in the turbid waters from the twenty-four hours' subsidences are open to us. One is to evaporate an aliquot portion; if the latter is not too small, and the soil is measurably free from the carbonates of lime and magnesia, and other soluble salts, this method may yield fairly satisfactory results. But one hundred (100) ccm., out of perhaps twenty (20) liters of water, as has been practiced by some, is at best a rather minute base line to go upon in so important a determination; moreover, it is so desirable to have the "clay" tangibly before one for examination that I consider it altogether preferable to precipitate it by means of a saline solution, and thus weigh the whole. The use of lime water, which naturally suggests itself, is so complicated by chemical reactions and other elements of uncertainty that I have found it preferable to employ simply pure rock-salt brine for the precipitation.

Fifty ccm. of a saturated brine (*i. e.*, 1.5 per cent of salt) is ordinarily sufficient to precipitate one liter of clay water; the precipitation is much favored by warming. Half the quantity, or even less, will do the same, but more time is required, and the precipitate is more voluminous.

In practice it will be found desirable to thus precipitate each lot of clay water as soon as drawn off. The clay precipitate (which greatly resembles the usual iron-alumina of chemical analysis) will then, at the end of twenty-four hours, have shrunk into so small a bulk that on drawing off the supernatant liquid, the succeeding clay water from twenty-four hours' subsidence may be mixed with it, causing it to rediffuse; the same being done at each succeeding drawing-off. This mode of operation greatly facilitates and shortens the gathering of the colloidal clay, which is precipitated much less easily and sharply from very dilute waters than from those heavily charged.

As the clay precipitate cannot ordinarily be washed with pure water, in which it quickly diffuses, it must be collected on a weighed filter, washed with weak brine, dried at 100°, and weighed. It is then again placed in a funnel and washed with a weak solution of sal-ammoniac, until all the chloride of sodium is removed. The filtrate is evaporated, the residue ignited and weighed; its weight, *plus* that of the filter, deducted from the total weight, gives that of the clay itself.

In some cases, especially of clays and subsoils deeply tinged with iron, the clay, *after drying at 100°*, will not readily diffuse in water, and can be washed with pure water until free from salt; it can then, of course, be weighed directly.

[*Properties of Pure Clay.*—The "clay" so obtained is quite a different substance from what usually comes under our observation as such, since its percentage seems rarely to reach 75 in the purest natural clays, 40 to 47 in the heaviest of clay soils, and 10 to 20 in ordinary loams. Thin crusts of it are occasionally found in river bottoms, where clay water has, after an overflow, gradually evaporated in undisturbed pools. When freshly precipitated by salt it is gelatinous, resembling a mixed precipitate of ferric oxide and alumina. On drying, it contracts almost as extravagantly as the latter, crimping up the filter, to which it tenaciously clings, and from which it can be separated only by moistening on the outside, when it may mostly, with care, be peeled off.

After drying it constitutes a hard, often horny mass, difficult to break, and at times

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somewhat resonant. Since the ferric oxide with which the soil or clay may have been colored is mainly accumulated in this portion, it often possesses a correspondingly dark brown or chocolate tint. When a large amount of iron is present, water acts rather slowly on the dried mass, which gradually swells like glue, the fragments retaining their shape. Not so when the substance is comparatively free from iron. It then swells up instantly on contact with water; even the horny scales adhering to the upper portion of the filter quickly lose their shape, bulge like a piece of lime in process of slacking, and tumble down into the middle of the filter.

There is a marked difference, however, in the behavior to water of clays equally free from ferric oxide; some exhibiting the phenomena just described in a more energetic manner than others. On the whole, those most free from iron appear to imbibe the water, and crumble most readily. As this property possesses highly important bearings, both on the agricultural and ceramic qualities of clays, I propose to investigate it more minutely hereafter.

The pure clay, when dry, adheres to the tongue so tenaciously as to render its separation painful. When moistened and worked into the plastic condition, it is exceedingly tenacious and "sticky," adhering to everything it touches.

Under a magnifying power of 350 diameters, no definite particles can be discovered in the opalescent clay water remaining after several weeks' subsidence. The precipitate formed by saline solutions then appears as an indefinite cloud (mostly of a yellowish tint), for which one vainly seeks a better focus. In stronger clay water one can discern a great number of indefinite punctiform bodies, very uniformly diffused throughout the liquid, and apparently opaque; the precipitate then formed by brine also shows a faintly dotted structure of its clouds.*]

Chemical Nature of the Clay Precipitate.—While usually considered as consisting essentially of kaolinite substance in a state of extremely fine division, the colloidal "clay" doubtless contains in most, if not in all cases, other colloids or "hydrogels," whose absorptive functions (albeit not plasticity) are in a measure similar to those of clay. Since, in many cases, the silica set free by treatment of the precipitate with acid is materially below that of the alumina dissolved by the same treatment, it follows that *free aluminic hydrate* is then present. The colloidal *ferric hydrate*, likewise, accumulated in the clay precipitate, and so are amorphous *zeolitic* compounds. While it is thus certain that the most careful mechanical separation of this "clay" can give only an approximation to the really plastic kaolinite substance, yet such approximation is infinitely closer than that attained by determination of total alumina by boiling sulphuric acid, still prescribed in text-books. As in such treatment all the chalky kaolinite particles are also decomposed, it does not lead to even the roughest approximate estimate of the soil's plasticity.†

Treatment of the Coarser Sediments.—The mixed sediments remaining after the separation of the clay, and of silts of less than 0.25 mm. hydraulic value (<0.25), by decantation, are ready for the elutriator, regarding which some general conditions have already been given; the main point to be guarded being the prevention of the formation of flocculent aggregates out of the granules of the finer sediments.

[*The Elutriator.*—The instrument as devised by me for the purpose of breaking up these flocculent aggregates is shown in the accompanying photo-engraving; the simpler form (Schöne's elutriator, as modified by me, with relay at base) can serve for grain-sizes above 8 mm. hydraulic value. (The latter tube is conveniently selected so as to have half the cross-section of the former, so that with the same position of the index-lever the velocity will be just doubled.) The cylindrical glass tube, of about 45 mm. inside diameter at its mouth, and 290 to 300 mm. high, has attached to its base a rotary churn, consisting of a brass cup, shaped like an egg, with point down (so as to slope rather steeply at base), and triply perforated, viz.: at the bottom, for connection with the relay reservoir; at the sides, for the passage of a horizontal axis, bearing four grated wings. This axis, of course, passes through stuffing boxes, provided with good, thick leather washers, saturated with mutton tallow. These washers, if the axis runs true, will bear a million or more revolutions without a material leakage; when a beginning is noted, additional washers may be slipped on without emptying the instrument, until the analysis is finished. From five to six hundred revolutions per minute is a proper velocity for the finest sediments, which may be imparted by clock work, turbine, or electric power. The driving pulley should not be directly connected with the axis, both because it is liable to cause leakage, and because it is necessary to be able to handle the elutriator quickly and independently. This is accomplished by the use of "dogs" on the pulley and churn axis. For the grain-sizes of 1 to 8 mm. hydraulic value, lower velocities are sufficient; too low a velocity causes an indefinite duration of the operation (and may be recognized by the increase of turbidity as the velocity is increased).

As the whirling agitation caused by the rotation of the dasher would gradually communicate itself to the whole column of water and cause irregularities, a wire screen of 0.8 mm. aperture is cemented to the lower base of the cylinder.

The relay vessel should be a thick, conical test-glass with foot; its object is to serve as a reservoir for the heavy sediments not concerned at the velocity used in the elutriator

*According to Whitney, the finest particles of colloidal clay are 0.0001 mm. diameter; Wollny gives 0.001 mm. as the limit, stating that the particles have the form of short, straight spicules. Probably the subject is far from its final form as yet.

†See on these points my article on "The Determination of Clay in Soils," Agr. Science, Vol. VI, No. 4.

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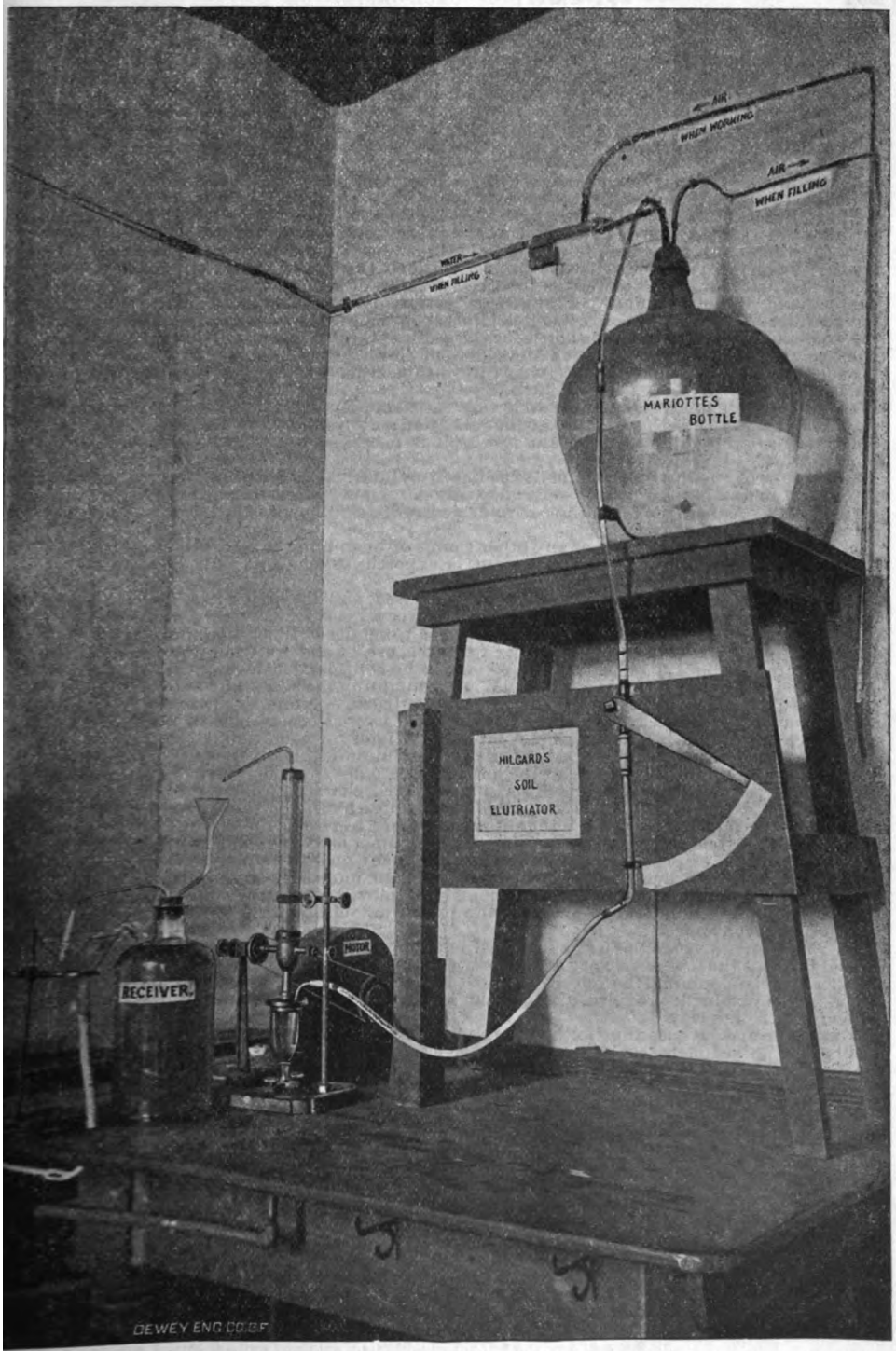

APPARATUS FOR THE PHYSICAL ANALYSIS OF SOILS BY HYDRAULIC ELUTRIATION.

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tube, and whose presence in the latter or in its base, the churn, would only cause abrasion of the grains and changes of current velocity, such as occur in the apparatus of Schöne, and compel the current measurement of the water delivered. It is connected above with the churn by a brass tube about 10 mm. in clear diameter, so as to facilitate the descent of the superfluous sediments, which the operator, knowing the proportion of area between the connecting tube and elutriator, can carry to any desired extent; thus avoiding the disturbance of the gauged current-velocities, as well as all material abrasion.

A current-delivery tube should extend quite half way down the sides of the relay vessel, to insure a full stirring-up of the coarse sediments when required. By means of a rubber hose, not less than 20 inches in length, this delivery tube connects with the siphon carrying the water from near the bottom of the Mariotte's bottle—a ten-gallon acid carboy. A stopcock, provided with a long, stiff index-lever moving on an empirically graduated arc, regulates the delivery of water through the siphon. Knowing the area of the cross-section of the elutriator tube, the number of ccm. of water which should pass through it in one minute at 1 mm. velocity, is easily calculated; and from this the lever-positions corresponding to other velocities are quickly determined, and marked on the graduated arc. The receiving bottle for the sediments (also shown in the engraving) must be wide and tall, so as to allow the sediment to settle while the water flows from the top into the waste pipe; the receiving funnel-tube must dip nearly to the bottom of the bottle.]

Thus arranged, the instrument works very satisfactorily, and, by its aid, soils and clays may readily be separated into sediments of any hydraulic value desired. But in order to insure correct and concordant results, it is necessary to observe some precautions, to wit:

1. The tube of the instrument must be as nearly cylindrical as possible, and must be placed and maintained in a truly vertical position. A very slight variation from the vertical at once causes the formation of return currents, and hence of flocculent aggregates on the lower side.

2. Sunshine, or the proximity of any other source of heat, must be carefully excluded. The currents formed when the instrument is exposed to sunshine will completely vitiate the results.

3. The Mariotte's bottle should be frequently cleansed, and the water used be as free from foreign matters as possible. For ordinary purposes it is scarcely necessary to use distilled water; the quantities used are so large as to render it difficult to maintain an adequate supply, and the errors resulting from the use of any water fit for drinking purposes are too slight to be perceptible, so long as no considerable development of the animal and vegetable germs is allowed. Water containing the slimy fibrils of fungoid and moss prothalia, algæ, vorticellæ, etc., will not only cause errors by obstructing the stopcock at low velocities, but these organisms will cause a coalescence of sediments that defies any ordinary churning, and completely vitiates the operation.

4. The amount of sediment discharged at any one time must not exceed that producing a moderate turbidity. Whenever the discharge becomes so copious as to render the moving column opaque, the sediments assume a mixed character, coarse grains being, apparently, upborne by the multitude of light ones whose hydraulic value lies considerably below the velocity used; while the churner also fails to resolve the flocculent aggregates, which must be perpetually reforming, where contact is so close and frequent.

This difficulty is especially apt to occur when too large a quantity of material has been used for analysis, or when *one* sediment constitutes an unusually large portion of it. Within certain limits, the smaller the quantity employed, the more concordant are the results. Between 10 and 15 grams is the proper amount for an instrument of the dimensions given above.

The Fine Sediments (0.25 to 4.0 mm. h. v.).—I have found that, practically, 0.25 mm. per second is about the lowest velocity available within reasonable limits of time; and that by successively doubling the velocities, up to 64 mm., a desirable ascending series of sediments is obtained; provided, always, that a proper previous preparation has been given to the soil or clay.

It would seem that according to the prescription given above for the preliminary sedimentation, no sediment corresponding to 0.25 mm. velocity should remain with the coarser portion. That such is nevertheless always the case, often to a large percentage, emphasizes the difficulty, or rather impossibility, of entirely preventing or dissolving the coalescence of these fine grain-sizes by hand-stirring, as in "beaker elutriation." It is only by such energetic motion as is above prescribed that this can be fully accomplished, and the delivery of 0.25 and 0.50 mm. h. v. exhausted.

[The operation is best begun by turning on a low velocity, 0.25 to 0.50 mm., and then quickly rinsing the sediments from a small beaker into the elutriator before the column reaches the top. The latter is then quickly closed, and a few seconds' subsidence allowed, with diminished velocity, so that the turbid column shall not be within 30 mm. of the top when the velocity desired is turned on; otherwise mixed sediment may pass at the beginning. At first the sediment passes off rapidly, and the column remains obviously and evenly turbid, from the point where the agitation caused by the churner ceases to the top. But this obvious turbidity generally exhausts itself in the course of a few hours, and it then requires some attention to determine the progress of the operation. I have never known the 0.25 mm. sediment to become properly exhausted in less than fifteen hours, and in one case it has required ninety. The more rigorously the

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process of preliminary disintegration, above described, has been carried out, the shorter the time required for running off the fine sediments, which otherwise may tax the operator's patience severely. In matter of fact, they never do give out entirely; doubtless for the reason that the stirrer continues to disintegrate compound particles which had resisted the boiling process. Besides, downward currents on the sides of the vessel *will* form, despite all precautions, so that the interior surface of the cylinder becomes coated with pendent flakes of coalesced sediment. These must, from time to time, be removed by means of a feather, so as to bring them again under the influence of the stirrer; but it is, of course, almost mathematically impossible that under these circumstances any of the sediments subject to coalescence should ever become completely exhausted. Practically, the degree of accuracy attainable at best renders it unnecessary to continue the operation beyond the point when only a fraction of a milligram of sediment comes over with each liter of water. It is admissible, and even desirable, to run off rapidly the upper third of the column at intervals of fifteen to twenty minutes; whereby, not only time is gained, but also the sediment in the reservoir is stirred, and brought under the influence of the churner, for more complete disintegration.

It is noticeable that recent sediments, river alluvium, etc., are much more easily worked than more ancient ones, as might be expected.]

Up to 4 mm. hydraulic value, the use of the rotary stirrer is indispensable, on account of the tendency to the formation of compound particles. Beyond, this tendency measurably disappears, so that for the *coarse sediments* of 8 to 64 mm. hydraulic value stirring may be employed, and an elutriating tube of smaller diameter may advantageously be substituted, in order to diminish the otherwise somewhat extravagant expenditure of water. The entire amount required for one analysis is from 25 to 30 gallons, provided a thorough previous disintegration has been secured. River water answers in ordinary cases; hard spring or well waters are undesirable. Distilled water is of course best, and by a simple arrangement of an air-tight reservoir connected with a pressure chamber, can be returned to the Mariotte's bottle and used over and over. The average times required for the several sediments are as follows:

Sediment 0.25 mm.	24 to 40 hours.
Sediment 0.5 mm.	15 to 25 hours.
Sediment 1.0 mm.	5 to 10 hours.
Sediment 2 to 64 mm.	6 to 10 hours.
Total	56 to 85 hours.

With proper arrangements much of this can be done automatically, at night, completing an analysis (except the clay and finest silt determinations) in the course of three or four days. Of course only a very small portion of this time is given by the operator to the care of the instrument; he can carry on other work just as when an evaporation is going on, with only an occasional glance to see that the water supply holds out and that there is no incipient leakage at the axis.

As the soils are most conveniently weighed, "dried at 100°,"* I have always the sediments in the same condition. Great care is necessary to obtain the correct weight of the (extremely hygroscopic) clay; the same is true, more or less, of the <0.25 sediment, which, moreover, is so diffusible in water that it cannot readily be collected on a filter. I find it best, after letting it subside into as small a compass as possible, to evaporate the last 25–50 ccm. in the platinum dish in which it is to be weighed.

From the other sediments, the water may be decanted so closely as to render their determination easy.

The loss in the analysis of clays and subsoils, containing but little organic or other soluble matter, is usually from 1.5 to 2.0 per cent, resulting partially, no doubt, from the loss of the fine silt which comes off more or less throughout the process, and is decanted with the voluminous liquid. When the turbidity is marked, it indicates imperfect preliminary disintegration; it may be removed, and the silt collected, by adding a weighed quantity of alum (about 25 milligrams per liter is sufficient), precipitating with carbonate of ammonia, and deducting from the weight of the (flocculent) precipitate the calculated amount of alumina.

[The analysis of soils rich in vegetable matter involves some modifications in the preliminary treatment and final weighings, which I shall not discuss here. Ignition of the soil previous to elutriation, as proposed by some, is obviously inadmissible, as it would render impossible the separation of the clay from the finer sediments.

As I have heretofore stated (Am. Jour. Sci., Dec., 1872; Proc. Am. Assoc. Adv. Sci., 1872, p. 71), I consider that, ordinarily, the investigation of the *subsoils* is better calculated to furnish reliable indications of the agricultural peculiarities of extended regions, than that of the surface soils, which are much more liable to local "freaks and accidents," and usually differ from the corresponding subsoils in about the same general points. For practical purposes, therefore, the difficulties incident to the treatment of soils rich in humus may in most cases be avoided.]

Character of the Sediments.—As regards the size of the particles constituting the successive sediments, the most convenient, because almost universally present, material for reference is quartz sand. I give below a table of measurements, concerning which I remark that the values given refer to the largest and most nearly round quartz grains to be found in each sediment.

* A somewhat clayey soil will continue to lose weight at 100° for five or six days. But after the first six hours the loss becomes insignificant for the purpose in question.

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As a matter of course, all sizes between that given and the one next below are to be found in each sediment. A few grains of the finer sediments are also invariably present, owing both to the progressive disintegration of conglomerated particles by the stirrer, and to the inevitable formation of the avalanche-like aggregates of the finer sediments.

While the measurement of the quartz grains (which are rarely wanting in a soil of clay) affords sufficient landmarks to the scientific observer, it seems desirable to attach to them, besides, generally intelligible designations, which shall approximately, at least, indicate the nature of the sediment. It is not easy to indicate, in popular language, distinctions not popularly made; but the grades of grain indicated in the common words "grits," "sand," and "silt," may, if numerically defined, serve, at least, to establish uniformity of expression among scientific observers and reporters. Thus it might serve a useful purpose to apply the designation of "grits" to all grains above 1 mm. diameter up to "gravel." Below 1 mm. down to 0.1 mm. might be "sand;" all below that "silt," viz.: impalpable powders. Then would follow clay, of which the distinctive character is not only impalpable fineness of grain, but also of plasticity. To the analyst, however, the designations by hydraulic values will in the nature of the case always remain the most convenient within the limits of the use of either sedimentation or hydraulic elutriation.

TABLE OF DIAMETERS AND HYDRAULIC VALUES OF SEDIMENTS.

Designation of Materials.		Diameter of Quartz Grains.	Velocity per Second, or Hydraulic Value.
Grits	1	1–3 mm.	(?)
	2	5–1 mm.	(?)
Coarse Sand	3	0.50 mm.	64 mm.
Medium Sand	4	0.30 mm.	32 mm.
Fine Sand	5	0.16 mm.	16 mm.
	6	0.12 mm.	8 mm.
	7	0.072 mm.	4 mm.
Coarse Silt	8	0.047 mm.	2 mm.
Medium Silt	9	0.036 mm.	1 mm.
Fine Silt	10	0.025 mm.	0.5 mm.
	11	0.016 mm.	0.25 mm.
	12	0.010 mm.	<0.25 mm.
Clay	13	(?)	<0.0023 mm.

[I remark that the absolute diameter of the elutriator-tube exerts a sensible influence on the character of the sediments, in consequence of the comparatively greater friction against the sides in a tube of small diameter. Strictly speaking, none of the sediments actually correspond to the velocity calculated from the cross-section of the tube and the water delivered in a given time, but to higher ones, whose maximum is in the axis of the tube, and which gradually decrease toward the sides, according to a law which may be demonstrated to the eye by slightly diminishing the velocity while a sediment is being copiously discharged, so that the turbid column remains stationary, while clear water is running off. The surface then assumes a paraboloid form, which is sensibly more convex in a tube of small diameter than in a wide one; the results obtained in the latter being, of course, nearest the truth.]

DETERMINATION OF THE WATER CAPACITY.

This determination as usually made is very indefinite in its results, varying (especially in pervious soils) according to the height of the soil column in which the water is absorbed. This is due to the obvious fact that at the base of a soil column, in which water has been allowed to rise to the maximum height, there is a maximum of this factor, decreasing regularly toward the top of the column, where it becomes a minimum. Now, since the ascent of water in columns of different soils varies from less than 375 mm. to over 1,200 mm., it is clear that any given uniform height of column arbitrarily agreed upon, as proposed by Ad. Mayer and others (*e. g.* 60 or 200 mm.), will give results standing in no direct rational relation to the maxima and minima of absorption of different soils. (See Wollny's Fortschr. Agr. Physik, XV, p. 1.)

It is evident that in this case, as in others, either a maximum or a minimum determination, or both, should be agreed upon; and such determination should be made in soil columns of *as little height as possible*—that is, approaching as nearly as may be to the theoretical postulate of a mere differential. I suggest as the lowest practicable measure for this purpose a column of 10 mm., placed in a circular brass box, with a thin perforated bottom, resembling the "lead sieve" of Plattner's blowpipe chest, and containing exactly 25 ccm. In this both the maximum and minimum absorption is determined for each soil, proceeding as follows:

Fill the box full of (air-dried) soil, of which the moisture content is determined in a separate portion at 100°.* Settle the soil by gentle tapping of the box on a table and then "strike" it level, as in measuring grain; weigh.

*The difference arising from drying at 100° as against 200° (see above) are not sufficiently great to influence sensibly the mere approximate results obtainable in the determination of water capacity.

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Place the weighed box plus soil on a triangle, submerged just beneath the surface of the water, in a somewhat wide vessel; allow it to stand until fully saturated (not less than an hour, in order to insure the complete wetting of compacted soil particles); then wipe *rapidly* with filter paper, or an absorbent towel, and weigh again without unnecessary delay. Calculate from the weighings the results with respect to both weight and volume.

Now place the same vessel with wet soil on a flat dessicator plate, and immediately cover it with an additional (unweighed) quantity of the same soil, in order to absorb all the water down to the minimum of liquid absorption.

[The dessicator plate, as well as the bell covering it, must be lined with wetted blotting paper, in order to maintain a fully saturated atmosphere, and during the latter portion of the process of minimization at least, the soil used must itself have been previously exposed to such an atmosphere long enough to fully saturate it with hygroscopic moisture (see above), since otherwise such moisture would be taken up from the wetted soil, and would thus vitiate the determination of liquid water capacity. A counterpoised glass plate on the scale pan of the balance serves to cover the soil cylinder while weighing.]

After the soil above has become imbued with moisture, it is cut off level with the edges of the box by means of a tense, fine silk thread. The upper portion being thrown off, the operation is repeated until the fresh quantities of soil fail to become moistened above the edge of the box, and cease to adhere, and weight ceases to decrease materially. Lastly, blow off carefully any loose particles remaining on the surface, and weigh. Dry the earth (in the box) thoroughly at 100°; weigh. The water thus driven off will represent the minimum of liquid absorption, plus the hygroscopic moisture originally contained in the soil (that has previously been determined by drying at 100°), contained in the weight of soil ascertained by drying the mass in the box. The latter will, as a rule, be found somewhat greater than that calculated from the first determination, because the unavoidable jarring and the weight of the soil poured on the wet mass, compacts the latter to some extent. By a simple calculation, the determinations may be referred to either of the two quantities for water capacity, both by weight and volume.

[It is clear that the soil so depleted of the water held in liquid absorption down to the minimum, is in precisely the same condition as a similar layer of soil forming to top of a soil column in which the water has been allowed to rise to its maximum height by capillary ascent. It seems at least probable that hereafter we may be able to deduce from these determinations the absolute height to which water will rise in a soil column in the course of time, but thus far we have no formula for such a deduction. Wollny has shown (Forsch. Agr. Physik, VIII, p. 197) that as a general rule the differences between the maxima and minima become less as the soil becomes more fine-grained, and this difference becomes an important physical datum in judging of the capillary efficiency of the soil. We can then by the above method attain in two or three days results which, by direct trial, would require at least as many months, and the differences between the maxima and minima thus ascertained far exceed those thus far on record.]

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SYNOPSIS OF THE DISEASES OF CULTIVATED PLANTS.

BEING INTENDED TO ENABLE ANY ONE TO DISCOVER THE CAUSES, AND LEARN THE METHODS OF TREATMENT, OF INJURIES PRODUCED BY INSECTS AND FUNGI.

By C. W. Woodworth, M.S.

Most of the letters coming to the University in regard to plant injuries contain, in some form or other, these two questions: "What is the matter with the plant?" and "What is the remedy?"

It is believed that by the use of this synopsis many of these inquiries could be answered by the farmer himself, and thus save him the trouble and delay of writing to the University for the information. There will always be, however, much that will have to be referred to scientific tests, and even then may remain a mystery.

The University of California is ever ready to render any assistance to the farmers of the State that lies within its power, and it is hoped that they will take fuller advantage of this fact, and when they find something injuring their plants they do not understand, that they will send us specimens.

Specimens to be sent through the mail should be placed in a wooden or tin box to prevent crushing. No holes need be made for ventilation, but it is well to put into the box a quantity of crumpled paper to absorb any moisture that may come from the specimen. Packages should be addressed to the *Director Agricultural Experiment Station, Berkeley, Calif.*

[Note.—In using this synopsis *always begin at 1.* The figures refer to the paragraphs to be consulted when the conditions suit. Thus, in No. 1, if the trouble is in a fruit rather than field or garden crop, reference is had directly to 38; then if the trouble is with the leaves rather than the fruit or tree, we pass on to 47; then if the leaves have a moldy appearance, we refer back to 15; and thus, from paragraph to paragraph, until no more references are made.]

1.

If the trouble is in a field crop, refer next to No. 2.
If it is in a fruit crop, to 38.
If it is in a garden crop, to 58.

2.

If the crop is uneven, refer to 3.
If the plants are wilted, to 25.
If the plants are yellowish, to 23.
If the leaves are spotted, to 28.
If parts of the leaves are dead, to 30.
If parts of the stem as well as of the leaves are dead, to 32.
If parts of the plant have been eaten up, to 33.

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3.

If the crop is uneven in coming up, refer to 4.
If the young plants are very uneven in size, to 13.
If the plants are older and very uneven in size, to 14.

4.

Examine the ground carefully where the plants should be, and—
If the seeds cannot be found it is probably the work of birds, mice, or other animals; generally they will leave marks by which their work can be recognized. When very bad they can be killed by means of seeds soaked in strychnine, or by seeds which have been wetted and powdered with arsenic.
If the seeds are still in the ground, refer to 5.

5.

If the seeds have not sprouted at all, refer to 6.
If the seeds have started to sprout but have not produced plants, to 7.

6.

If the soil is very dry, the trouble may be a lack of moisture, and it is quite possible for one part of the field to have plenty and another very little. Not only is the variation due to a difference of level, but to differences in the composition of the soil or of the mechanical condition. Unevenness due to dryness may also signify that the planting was very uneven in depth, some of the seed not being deep enough to get sufficient moisture.
If the soil is not very dry the trouble is probably bad seed. Old seed or unripe seed are the commonest forms of bad seed.

7.

If the seed were planted too deep, the plants may not have been strong enough to get through the ground.
If the seed were not planted too deep, refer to 8.

8.

They have been probably attacked by an insect, which should be carefully looked for.
If the insect is like an ant, refer to 9.
If it is like a worm or grub, to 10.

9.

If it is white it is one of the insects of the family Termitidæ. They live chiefly about stumps, and if the ground is once well cleared from these there will be no further trouble from this insect.
If it is brown, or any other color but white, it is a true ant and belongs to the family Formicidæ, or a closely allied one. These, like the white ants, will not be very troublesome after the ground is well under cultivation.

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10.

If it has no legs it is a maggot of a fly, most likely of the family Anthomyidæ. Nothing has been tried for these, as they have never done much injury.

If it has six legs, refer to 11.

If it has more than six legs, to 12.

11.

If it is hard and wire-like, it is one of the wire-worms, the young of the Elateridæ. These do an immense amount of injury. There is no practical remedy. Fertilizers will often enable the plant to recover when not badly injured, and do good in this way. Land which is allowed to become weedy is very apt to become badly stocked with wire-worms for the next year.

If it is thick and soft, it is one of the white grubs, the young of the Scarabæidæ. The same may be said about these as about wire-worms.

12.

If it is protected by a tube of silk, it is one of the root web-worms, the young of one of the Tortricidæ. Nothing can be done as a remedy. Rotation of crops is a sufficient preventive measure.

If it is not protected by a silken tube, it is one of the cut-worms, and is the young of certain of the Noctuidæ. Cut-worms are among the most injurious insects, especially to young plants, but the greatest injury is generally after the plant is out of the ground. Nothing can be done cheaply enough to protect field crops. Keeping the ground clean is the best preventive.

13.

Examine the plants carefully, and if they do not show any other of the symptoms mentioned under 2, then examine the stem near the ground, and then the root.

If it is covered with lice, they may be the cause. Plant lice, whether above or below the ground, do much injury. Nothing can be done cheaply enough to pay on field crops, unless it be the use of fertilizers and good cultivation, which may make a crop in spite of the lice.

If there are no lice on the plants, refer to 8.

14.

Unevenness in the fertility of the land is the commonest cause of this appearance, but it may be due to other things, especially to the attacks of insects while the plants were small, and from which they have not yet recovered. If it is not one of these, a careful examination of the plant will generally show what the matter is.

If the leaves or stems look as though molded, refer to 15.

If there is no moldy appearance, to 17.

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15.

If when it is examined with a microscope, part of the leaf or stem where the moldy appearance is be covered with very fine threads, refer to 16.

If there are no threads, and the moldiness is due to little powdery particles, it is one of the Peronosporiaceæ, or downy mildews. Nothing can be done cheaply enough for field crops.

16.

If there are among the threads a great number of very small yellowish or reddish animals, it is the red spider, and the threads are simply the web. Most of these insects belong to the genus Tetranychus. Peanuts are often attacked, and simply making the plants very dusty is said to be a sufficient remedy.

If besides the threads there are only powdery particles, it is one of the Erysipheaceæ, or powdery mildews. Sulphur dusted on the plants is a remedy, but it will seldom be cheap enough to pay on field crops.

17.

Look for the other symptoms mentioned under 2, and if none of these are noticed then—

If there are numerous insects on the plant above the ground, refer to 18.

If there are no insects above the ground, to 20.

18.

If these insects are about the head or flower only, refer to 19.

If they are on other parts of the plants they are bugs, and belong to the order Hemiptera. This order includes the plant lice and a great many other insects. Nothing can be done cheaply enough for field crops unless they can jump, when if a sheet of tin be drawn over the field, the upper side of which has been covered with tar, or anything sticky, great quantities will be caught and destroyed. This can be done in grain fields and in meadows.

19.

If they are small reddish or yellowish maggots, they are the young of very small flies, and belong to the Cecidomyidæ. Nothing can be done to kill them. One kind of worm lives on only one kind of plant, so if they become bad the land should be put in another kind of crop next year.

If they are small, active, blackish insects, they are the true thrips, belonging to the order Physopoda. They are very different from the insect called thrips that lives on the grapevine. Nothing can be done to kill them.

20.

Examine the roots, and—

If they are covered with lice, they are of the family Aphidæ, or plant lice, and nothing can be done to kill them. The same kind lives on related plants, so in rotating make a great change, as from grain to potatoes, or to clover.

If they are not covered with lice, refer to 21.

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21.

If the roots are swollen in places, refer to 22.
If the roots are not swollen, to 8.

22.

If it is a plant of the pea family the swellings are probably natural, and not the cause of the injury; refer then to 8.
If it is not of the pea family the trouble is probably due to a small Nematode worm. Plant another crop on the land, and keep the weeds down for a number of years, and the worms will die out.

23.

If there are lice on the plant, they may be the cause. They belong to the family Aphidæ, and good cultivation and the use of fertilizers is all that can be done.
If there are no lice on the plants, refer to 24.

24.

If the plants are small it may be due to too much moisture in the ground.
If the plants are old it may be only the natural ripening of the leaves.
If it is not due to either of these causes look for very small, reddish, yellowish, or blackish spots, and if they are present they may be the cause. These are the rusts and smuts belonging to the groups Uredineæ and Ustilagineæ. Nothing can be done as a remedy. In the case of smuts, as a preventive treatment it has been found that soaking seed, before planting, in water at 131° for fifteen minutes, gives very good results.
If the plants have been injured by insects or any similar cause, as drought, they are very apt to ripen their leaves and become yellow earlier than they should.

25.

If the weather is excessively hot and dry, this may be the cause.
If the weather is not excessively dry, refer to 26.

26.

If the plants are covered with insects, they belong to the order Hemiptera. This includes, besides the plant lice, all the true bugs. Nothing can be done as a remedy, for if they are bad enough to wilt the crop, there is no longer much hope for a yield.
If the plants are not covered with insects, refer to 27.

27.

If the roots are rotten, it is probably due to a fungus. Several forms of root rot have been studied, but no remedy is known. The same form of rot often attacks many kinds of plants, so in rotating crops it will have to be determined by experiment what crops are not affected by the particular form of rot present.
If the roots have been eaten, refer to 10.

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28.

If the spots are of very irregular shapes, it is likely that they are due to mechanical injury. This is especially the case as the plants get old, when it is often hard to find a sound leaf. Hail and heavy winds are the chief causes.

If the spots are somewhat uniform in size or appearance, refer to 29.

29.

If the spots are small and composed of a reddish yellow or black powder, it is one of the rusts or smuts, and belongs to the groups Uredineæ and Ustilagineæ. Nothing can be done as a remedy. It has been found in the case of certain smuts that treating the seed for fifteen minutes in water at 131° gives very good results as a preventive treatment.

If there are other spots they may be produced by imperfect fungi. There are almost an unlimited number of things that may produce an occasional spot on a leaf, but if there are enough of these spots to produce injury, and they are near enough alike to have been produced by the same cause, some one of these imperfect fungi is probably the cause. Nothing can be done as remedy.

30.

If the dead portions of the leaves include spots, it is probably due to a fungus; refer to 29.

If the dead portions of the leaf do not include spots, to 31.

31.

If the leaf is covered by a whitish powder, the leaf was probably burned by alkali.

If the leaf has not this powder, it is probably a case of sunburn.

32.

It is due to an injury to the stem. Examine it at the point where the dead part begins, and—

If you find a caterpillar there, or a hole with coarse, brown powder, it is due to the caterpillar, the young of one of the Noctuidæ. No remedy is useful.

If there is no caterpillar there, it is likely that it was nearly broken at that point, and this accounts for the death of the stem.

33.

If the top of the plant has been cut off, refer to 34.

If the leaves have been eaten, to 35.

34.

If there is no insect left in the standing stalk, it is the work of a cutworm, and belongs to the family Noctuidæ. These are among the most destructive insects. There is no remedy for field crops. Keeping the ground free from grass the previous year is a good preventive measure.

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If it is a wheat stem, and there is an insect left in the standing stalk, it is one of the saw flies belonging to the family Tenthredinidæ. Burning the stubble is a perfect remedy.

35.

If on the plant there is an insect which is doing the injury, refer to 36.
If there is no insect about to which the injury may be laid, to 37.

36.

If it is a caterpillar, it is one of the Lepidoptera, and can be easily killed by the use of Paris green or London purple. For use on field crops it can generally be most cheaply applied as a dry powder; from one to five pounds to the acre will do the work. If one has no special apparatus it can be satisfactorily distributed by walking or riding over the field carrying a pole, at both ends of which are hung muslin bags containing the poison. This method is used to a great extent in the cotton fields of the South. If it is sprayed on the plants, use one pound of the poison to two hundred gallons of water. Don't use these poisons on any crop when the poison would be dangerous.

If it is a grub with six legs, or a beetle, it belongs to the family Chrysomelidæ, and the same remedy may be used as for caterpillars.

If it is a grasshopper, it belongs to the family Acrididæ, or if green to the family Locustidæ. The same remedy may be used, but grasshoppers sometimes get so numerous that they would eat everything up before they would be killed. It has been suggested that the poison be mixed with bran and put where they can get it. Great numbers of the young hoppers can be killed by dragging over the fields large sheet-iron pans containing a little kerosene. The back edges of the pans reach up a couple of feet to prevent the insects from jumping clear over the pan. The eggs are laid in the ground, and may be killed by winter plowing.

37.

If fowls or other birds are about in great numbers, it may be due to them. Their work can generally be told by the rough way they tear the leaf.

If it is not due to birds, it is probably the work of insects. They may have done their work and gone, or they are hiding in the ground, and only feed at night. If Paris green or London purple can be safely used, these are good remedies; used as described above, in 36.

38.

If there is something the matter with the fruit, refer to 39.
If there is something the matter with the leaves, to 47.
If there is only a general unhealthiness of the whole tree, to 54.

39.

If the young fruit drops or fails to form, refer to 40.
If the fruit is shriveled or small, to 41.
If the fruit is spotted, to 42.
If the fruit is rotting, to 43.
If the fruit has been eaten into, to 44.

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40.

If a small brownish bug can be seen about the buds and young fruit, it may be the cause. There is a species of the family Capsidæ that often does considerable injury.

If this bug is not present, it is due to a number of physiological causes but poorly understood, and probably not to any other insect or fungus.

41.

If bugs or lice are present on the fruit, the injury may be due to their sucking the sap. These insects belong to the order Hemiptera. They may be killed by a kerosene emulsion. The emulsion may be made as follows: Make a soap solution of half a pound of soap to a gallon of water. Heat it to boiling, and add two gallons of kerosene. Take the force pump and pump it through for five to ten minutes. For use, add ten times as much water as you have emulsion. Apply with a spray pump.

If there are no lice or bugs on the fruit, it is probably due to the bad condition of the tree; refer to 54.

42.

If the spots are small whitish, or whitish with a larger red border, and if this whitish part may be lifted up, disclosing a small yellowish insect beneath, it is one of the scale insects which belong to the family Coccidæ. After the scales are on the fruit, it is generally not worth while to try to kill them. Before they get on the fruit, however, it is well to use a preventive treatment. See 55.

If the spots are not small whitish scales they are probably caused by fungi. There are a great many kinds that attack fruits, but the same remedies are applicable for them all. In some cases they will be found very successful, but in others less so. Bordeaux mixture may be made of equal parts of lime and bluestone (copper sulphate). Use one pound of each of these to every five gallons of water; slake the lime in part of the water, dissolve the bluestone in the rest, and when they are both cool, mix. This will be found one of the best. Another, an ammoniacal solution of copper carbonate, may be made as follows: Take one ounce of copper carbonate and mix with six ounces of ammonium carbonate, and dissolve the whole in ten gallons of water.

43.

If the rotting has commenced from a hole, and spread into the surrounding tissue, it is one of the ordinary rot fungi, and the method of treatment must be to prevent the formation of the hole; refer next to 44.

If the rotting does not commence from a hole it is one of the truly parasitic fungi, and the treatment given for fungi in 42 is the thing to do.

44.

If it is eaten into from the outside, refer to 45.

If it is eaten by an insect deep within the fruit, to 46.

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45.

If it is done by birds, and they become destructive enough to make it desirable to kill them, it may be done by exposing food which has been strongly poisoned with arsenic.

If it is a bee, the fruit has probably been first attacked by other insects or birds, or has become very much overripe.

If it is a wasp, they may be destroyed by exposing poisoned fruit. This cannot be safely done where bees could get at it. The destruction of their nests with bisulphide of carbon is a safe remedy.

If it is a beetle, it is most likely the common spotted Diabrotica, which is often supposed to be one of the ladybirds. When they become destructive, all the plants they frequent that can be safely poisoned should be; for method see 36. Those already on the fruit may be killed with kerosene emulsion; for method see 41.

46.

If it has no legs it is the young of a fly of the family Trypetidæ. There is no remedy for this but the destruction of all infested fruit.

If it has six legs it is the young of one of the weevils belonging to the family Curculionidæ. The injury done by these insects can be controlled to a certain extent by spraying the fruit in the spring before the old beetles lay their eggs. For this purpose Paris green or London purple is used, at the rate of one pound of the poison to two hundred or three hundred gallons of water. In spraying these arsenites the nozzle may be held at a distance from the tree, and no more should be applied after the leaves begin to drip.

If it has more than six legs it is a caterpillar of the order Lepidoptera. The codlin moth is the best known species attacking fruits. The use of the arsenites, as given just above, is a very good remedy.

47.

If they have a blackish, dirty appearance, refer to 48.
If they are bent and twisted all out of shape, to 49.
If they are spotted, to 42.
If they have a molded appearance, to 15.
If they have been eaten, to 50.

48.

The appearance is due to dust, or if very black, also to the fungus called the smut fungus. These depend on the presence of insects on the tree, which secrete a watery substance, and which catches and holds the dust, and furnishes food for the smut fungus.

If there are large, wart-like scales all over the stems it is one of the scale insects of the family Coccidæ. The remedy is the kerosene emulsion, as described in 41, with the addition of a very small amount of arsenic to the soap solution, or instead, if the tree is in bearing, a little buhach to the kerosene.

If there are lice on the leaves, this is the cause. Plant lice belong to the family Aphidæ. They may be killed with kerosene emulsion; see 41.

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49.

If it is peach leaf, it is the curl leaf, a very injurious fungus disease, for which there is no remedy. Many growers in this State, however, claim good results from a winter wash of lime eight pounds, salt three pounds, and sulphur four pounds, for each twelve gallons of water; boil one fourth of the water, to which has been added one fourth of the lime and all the sulphur, for one and one half hours; put the salt with the rest of the lime and slake with hot water; add to the above and boil a half hour longer, then add the remainder of the water and apply.

If it is on other plants and there are lice on the underside, the lice are the cause. They may be killed with kerosene emulsion, but they are very hard to get at if they are not killed before the leaves are badly curled.

50.

If the insect that is doing the injury is still on the plant in plain sight, refer to 51.

If the insect is not in sight, to 53.

51.

If it is a grub with six legs, it is the young of one of the Chrysomelidæ. This can be killed with kerosene emulsion, or with Paris green; for methods, see 41 and 46.

If it is a caterpillar with ten to sixteen legs, refer to 52.

If it is like a caterpillar but has more than sixteen legs, it is the young of a sawfly belonging to the family Tenthredinedæ. The remedies are the same as for the Chrysomelid above.

If it is a grasshopper, see 36.

52.

If the caterpillars live singly, use the same remedies as in 51.

If the caterpillars live all together in a bunch, the easiest method is to remove the leaves or stem on which they are congregated, and crush or otherwise destroy them.

53.

If on examining the ground beneath the eaten leaves, a quantity of brownish or greenish pellets can be seen, it is the work of a caterpillar that has either finished its work and gone, or it is one of those that lie concealed during the day and feed at night. Paris green or London purple, according to the directions in 46, is the remedy.

If there are none of these pellets on the ground, it is not the work of an insect but perhaps some larger animal.

54.

If there are lice very thick on the stems or on the roots, this is very likely the cause. For plant lice on the stems, kerosene emulsion, according to directions in 41, is sufficient; but when they are on the roots there is no satisfactory remedy, and the trouble is that the same insect often inhabits both localities.

If there are no lice, refer to 55.

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55.

If there are scale insects on the stems, small whitish spots which, when lifted up, will show the yellowish scale beneath, or larger, oval, blackish, wart-like insects, these, if abundant, may be the cause of the condition of the tree.

If there are no scales, refer to 56.

Besides the kerosene emulsion noticed in 48, the resin washes, on account of their cheapness, have come to be used to a good extent. The following are the latest formulæ from the Department of Agriculture at Washington:

	For Summer Use.	For Winter Use.
Resin	18 pounds.	30 pounds.
Caustic soda (70 per cent strength)	5 pounds.	9 pounds.
Fish oil	2½ pints.	4½ pints.
Water enough to make	100 gallons.	100 gallons.

The material is put in a kettle and covered with four or five inches of water. The lid is put on the kettle and the mixture is boiled for a couple of hours or more, and then the rest of the water is added, a little at a time.

56.

Examine the trunk very carefully for borers. These may be known generally by a fine brownish powder which is pushed out of the hole. Look from the crown beneath the surface of the ground clear up to the smaller branches, and—

If there are many borers, they are probably the cause. The only remedy for borers is to find the holes and kill the worms, either by running a wire in or by cutting the worm out. A preventive measure is to cover the trunk of the tree with a soapy or poisonous wash.

If there are no borers, refer to 57.

57.

If one side of the trunk is dead, this may explain the condition. This condition is very common, especially on old trees. An unhealed injury to one side gradually increases by the drying out of the wood of the trunk and thus cutting off the connection between the root and the top. A tree in this condition had better be removed.

If the roots have knots they would, if numerous, produce a bad condition of the tree. A number of different things are known to produce knots, but the various kinds are not easily distinguished. There is no remedy, and for some kinds it would not be well to reset a tree at once where a tree had died with root knots.

58.

If the injury is of the roots or of the plant near the roots, refer to 59.

If the injury is to the green parts of the plant, to 61.

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59.

If the insect has no legs, it is the maggot of a fly of the family Anthomyidæ. There is no satisfactory remedy, but they are seldom injurious. The only thing to do then is to refrain from planting that crop for awhile.

If the insect has six legs, refer to 60.

If the insect has more than six legs, it is a cut-worm belonging to the family Noctuidæ. These insects are very destructive to young plants in the spring. Young cabbage and tomato plants can be preserved by wrapping paper around the stems as they are set out. This is about all that can be done, aside from finding and killing them by hand. Placing fresh green food well poisoned on the ground will destroy some.

60.

If it is ant-like, refer to 9.

If it is not ant-like, to 11.

61.

If the leaves are spotted, refer to 42.

If the injury is produced by an insect eating inside the plant, to 62.

If the injury is produced by an insect eating outside of the plant, to 51.

If the injury is produced by an insect that does not eat the plant, to 41.

62.

If it has more than six legs, it is one of the Lepidoptera. There are quite a number that burrow into plants. The only thing that can be done is to find them and cut them out by hand.

If it has six legs or less, it is one of the Coleoptera. Nothing can be done, but fortunately very few of them ever become at all injurious.

63.

If it has more than six legs, it is one of the Lepidoptera. In the garden these can often be quite economically collected and destroyed by hand. Wherever poison can be safely used, Paris green or London purple may be used, either dusted on or sprayed at the rate of a teaspoonful to a bucket of water.

If it has only six legs, refer to 64.

64.

If they are grasshoppers they may be collected by means of a butterfly net and numbers destroyed in this way. The bran and arsenic mixture can also be used effectually in a garden.

If it is not a grasshopper, it is a beetle, and the same remedies as for Lepidoptera in 63 may be used.

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INDEX TO THE MORE IMPORTANT REMEDIES.

[The numbers refer to paragraphs.]

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A SYNOPSIS OF THE FAMILIES OF INSECTS.

PREPARED FOR THE USE OF THE UNSCIENTIFIC PUBLIC.

By C. W. Woodworth, M.S.

"What is it?" and "What are its nature and habits?" are the two important questions that every one asks when an insect begins to be abundant or injurious. For the farmer they are often of immense importance, so that if it can be made possible for him to answer these questions himself, and at once, every one will realize that much has been accomplished.

The following synopsis has been prepared with this object in view, and it is believed that, in the hands of the intelligent farmer, it will be an important help.

The synopsis is in simple English, all scientific terms being left out, unless really necessary, and these are fully explained by the figures and by the "Explanation of terms" at the end. By this means it is believed that it may be successfully used by one having no previous knowledge of insects.

To determine an insect *commence at the beginning of the synopsis and be sure of every character.* Every one will meet two difficulties. One is the small size of most insects, which makes it hard to see the parts. A three fourths inch Coddington magnifier, costing about $2, will aid in overcoming this difficulty. The other is to tell whether a part is "long" or "short," or any such character. An examination of a number of other insects will soon enable one to decide these questions. Do not be afraid of the size of the synopsis, for to determine any one insect only a small part of it has to be read, generally less than a page.

This synopsis will give some idea of what the insect is, no matter in what stage it may be. One does not have to wait till the wings are grown before it can be told where the bug belongs. Most insects begin their lives as eggs. When these hatch into a worm-like or grub-like form, they are called larvæ; then comes a resting stage, called the pupa; and, finally, the full-grown insect comes out. Many kinds are very much like the full-grown insect as soon as they come from the egg, and are then called nymphs.

This synopsis is in no sense a text-book of entomology. It is expected, however, that it will be very acceptable to both teacher and pupil in finding out what the insects are that they may be studying. It has been prepared from manuscript synopses used the past year by the students in entomology at the University, and which were found very useful. In the shape it is now presented it becomes particularly suitable for use in schools.

As this synopsis of the families covers all the orders of insects, there are quite likely many errors and inaccuracies, but no pains have been spared to make them as few as possible. The author invites the fullest

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criticism, and especially requests those who use this synopsis to communicate with him in regard to any difficulties they may meet. It is the intention to make this a part of a more extensive work on insects.

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SYNOPSIS OF THE ORDERS OF INSECTS.

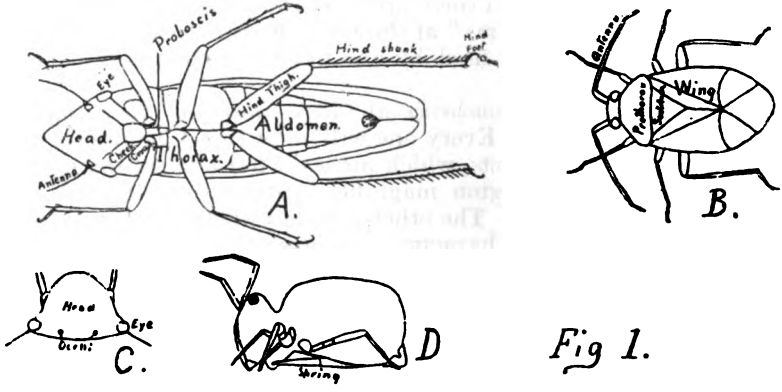

Fig 1.

1.

If the insect has movable legs, refer to 8.
If the insect has no movable legs, to 2.

2.

If the body is jointed so that the insect can bend from side to side, refer to 3.

If it has no joints it is an insect in the egg stage, unless—

(*a*) It is one of the scale insects, and has a long, hair-like proboscis for sucking food from the plant, when it belongs to the Hemiptera; or unless,

(*b*) It is the pupa stage of one of the flies which cannot be easily told from an egg without first hatching it, when, if a fly with two wings comes out, it belongs to the Diptera; or unless,

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(*c*) It is the cocoon of a parasitic wasp, when the shell is large and loose and it belongs to the Hymenoptera.

Perhaps it is not an insect at all, as some other things often look like the eggs of insects. It may be the egg of a spider or other related animal, and these can hardly be told from insect eggs without first letting them hatch. It may be the seed of some plant or a fungus or an egg-like swelling on a plant; but these do not hatch into an insect.

When in the egg state the group to which the insect belongs cannot generally be made out.

3.

If the legs, etc., of the full-grown insect can be seen in cases, refer to 4.

If they cannot be seen, it is one of the Diptera or Hymenoptera in the larva stage, unless it is one of the few footless larvæ of Coleoptera or Lepidoptera, which live inside of plants. These can all be told apart if they are raised to the pupa stage.

4.

If these cases are glued to the body, refer to 5.

If these cases hang out free from the body, to 6.

5.

If it has one pair of wing cases, it is one of the Diptera in the pupa stage.

If it has two pairs of wing cases, it is one of the Lepidoptera in the pupa stage.

If it has no wing cases, it is the pupa of one of the wingless forms of these two orders, and then can only be easily distinguished if allowed to hatch.

6.

If all the thorax forms one solid joint, it is one of the Hymenoptera in the pupa stage.

If the prothorax is not fastened tightly to the rest of the thorax, refer to 7.

7.

If the wing cases show but few or no veins, it is one of the Coleoptera in the pupa stage.

If the wing cases show many veins, it is one of the Neuroptera in the pupa stage.

8.

If it has wings, refer to 14.

If it has no wings, to 9.

9.

If it is grub-like or worm-like, refer to 13.

If it is not grub-like or worm-like, to 10.

10.

If the mouth has jaws that are so sunken into the head that only the ends can be seen, the insect is one of the Thrysanura.

If the mouth has jaws for biting, refer to 11.

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If the mouth forms a proboscis (Fig. 1 A) for sucking, or if there is none at all, to 12.

11.

If the insect has gills, or if it is ant-like or louse-like, it is one of the Pseudoneuroptera in the nymph stage, unless it is ant-like and has the abdomen quite narrow where it is fastened to the thorax, when it is one of the Hymenoptera.

If the insect has no gills, and is not ant-like or louse-like, it is one of the Orthoptera in the nymph stage, unless—

(*a*) It is a wingless, full-grown insect of the same order; or unless,

(*b*) It is a wingless species of the Neuroptera, when the prothorax is very small, and not as wide as the rest of the thorax.

The beetles do not belong here, as the horny covering of the abdomen is really the front wings of the insect, and they belong to the order Coleoptera.

Spiders which have eight legs are not true insects. A few mites have six legs, or even only four, but these may be known by their small size, being smaller than a pin head.

12.

If there are claws on any of the feet, the insect is one of the Hemiptera in the nymph stage, unless—

(*a*) It is a wingless, full-grown insect of the same order; or unless,

(*b*) It is a wingless moth, when it will be covered with scales, and belong to the order Lepidoptera; or unless,

(*c*) It is a wingless fly, if the feet have five joints, and belongs to the order Diptera.

If there are no claws on the feet and the last joint is swollen, it is one of the Physopoda in the nymph stage.

13.

If it has six legs, it is one of the Coleoptera or Neuroptera in the larva stage, and they must be raised to the pupa stage to tell them apart.

If it has six legs of one kind near the head, and two or more of another kind farther back, it is one of the Lepidoptera in the larva stage, unless there are more than ten of this second kind, when it is a larva of the Hymenoptera.

If there are more than six legs of the kind near the head, it is not an insect, but a Myriapod.

14.

If all the thorax forms one solid joint, refer to 15.

If the prothorax is not fastened tight to the rest of the thorax, but can move, to 17.

15.

If it has two wings, it is one of the Diptera.

If it has four wings, refer to 16.

16.

If there are scales on the wings, it is one of the Lepidoptera.

If there are no scales on the wings, it is one of the Hymenoptera.

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17.

If the mouth has biting jaws, refer to 19.
If the mouth is a proboscis, or if there is none, to 18.

18.

If there are claws on any of the feet, it is one of the Hemiptera.
If there are no claws on the feet and the last joint is swollen, it is one of the Physopoda.

19.

If the front wings are leathery or horny, refer to 20.
If the front wings are thin, to 21.

20.

If the abdomen has tails, hooks, pincers, or something of the kind at the end, it is one of the Orthoptera, unless they are very small and the front wings are at the same time hard and horny, when it is one of the Coleoptera.
If the abdomen has nothing at the end, it is one of the Coleoptera.

21.

If the antennæ are very short, it is one of the Pseudoneuroptera.
If the antennæ are not very short, it is one of the Neuroptera, unless the feet have less than five joints, when it belongs to the Pseudoneuroptera.

SYNOPSIS OF THE FAMILIES OF THRYSANURA.

The Thrysanura are all small insects, the largest not being over half an inch in length. They never have wings. They live generally in damp places and feed chiefly on decaying vegetable substances, and are therefore of but little economic importance.

22.

If it has legs on the abdomen, it belongs to the Scolopendrellidæ.
This is a very small family of insects that look very much like centipedes. They are very rare and the food habits are not known.
If it has no true legs on the abdomen, refer to 23.

23.

If it has a pincer at the end of the abdomen, it belongs to the Japygidæ.
These insects are found in caves, are very rare, and their food habits are not known.
If it has three slender, many-jointed tails at the end of the abdomen, refer to 24.
If the abdomen has a spring beneath for jumping, to 25.
If the abdomen has none of these, to 28.

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24.

If the body is covered with scales, it belongs to the Lepismidæ.

This is a family of very common insects, living in damp places, and often doing considerable injury to things containing paste, to clothing, etc.

If there are no scales on the body, it belongs to the Campodiidæ.

This family contains some rather common insects, but the food habits are unknown.

25.

If the body is less than twice as long as broad, refer to 26.
If the body is more than twice as long as broad, to 27.

26.

If the last joint of the abdomen is long, it belongs to the Smynthuridæ.

The insects belonging to this very small family are very commonly found on plants, and may feed upon them.

If the last joint of the abdomen is short, it belongs to the Papiriidæ.

This is a very small family of insects, whose food habits are unknown.

27.

If the spring is fastened to the fourth joint of the abdomen, it belongs to the Poduridæ.

The food habits of the insects belonging to this very small family are not certainly known.

If the spring is fastened to the fifth joint of the abdomen, it belongs to the Entomobryidæ.

This is the largest family of the order, but scarcely anything is known about their food habits. Like most of the other members of the order, they are of little economic importance.

28.

If the jaws are hard, for use in biting, it belongs to the Lipuridæ.

This is a very small family, with unknown food habits.

If the mouth is fitted for sucking, it belongs to the Anouridæ.

This is a very small family, with unknown food habits.

SYNOPSIS OF THE FAMILIES OF PSEUDONEUROPTERA.

The insects belonging to the different families of Pseudoneuroptera are very different from each other in form and habits. The families of both nymphs and full-grown insects of this order may be told by the following synopsis:

29.

If the abdomen has rather long tails, refer to 30.
If there are only very short tails on the abdomen, or none at all, to 32.

30.

If the front legs are very much longer than the others, it belongs to the Ephemeridæ.

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The Ephemeridæ, or May flies, spend most of their life in the water and probably eat both animal and vegetable matter. After they get their wings they lay their eggs and soon die.

If the front legs are like the others, refer to 31.

31.

If the antennæ are about as short or shorter than the head, it belongs to the Libellulidæ.

These are the insects known as dragon flies. They pass their nymph stage in the water, feeding on other insects. After they get their wings they continue to capture and eat other insects.

If the antennæ are much longer than the head, it is one of the Perlidæ.

The Perlidæ, or stone flies, live in the water in their nymph stage, probably feeding on vegetable matter. They lay flat against stones in the bottom of streams. The winged insect does not appear to take food at all.

32.

If the shanks are slender, refer to 33.

If the shanks are thicker than the thighs, it is one of the Mallophagidæ.

The Mallophagidæ, or bird lice, are always wingless. They have larger heads than other lice, and live chiefly on birds, though some kinds live on other animals.

33.

If the antennæ are longer than the thorax, it belongs to the Psocidæ.

The Psocidæ often have wings when full grown, but are sometimes wingless. They live on lichens and other vegetable matter. The little white book lice belong to this family.

If the antennæ is not longer than the thorax, it is one of the Termitidæ.

These insects are known as white ants, and, like the true ants, the winged forms are seen only about once a year, and these soon die or shed their wings, and then for the rest of the year only wingless forms can be seen. Of these there are often several kinds in the same nest. The white ants do a great amount of damage by burrowing into wood, and sometimes they even attack living plants.

SYNOPSIS OF THE FAMILIES OF ORTHOPTERA.

The Orthoptera are generally readily known by the large hind wings, which are folded up like a fan and covered by the leathery front wings when not in use. The family of both the nymphs and the full-grown insects may be told as follows:

34.

If the hind thighs are very much longer than the others, refer to 38.

If the hind thighs are not very much longer than the others, to 35.

35.

If the body is flattened, refer to 36.

If the body is not flattened, to 37.

36.

If the head is sunken into the thorax, it is one of the Blattidæ.

The Blattidæ are the well-known cockroaches. The eggs are laid in a bean-like pod. The nymphs and full-grown insects feed on various substances, and are quite destructive about houses.

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If the head is not sunken into the thorax, it is one of the Forficulidæ.

The Forficulidæ include the earwigs. It is a small family, easily told by the pincers at the end of the abdomen. They feed on plants, and do the most injury eating the blossoms of flowers and fruits. They have never been abundant enough in this country to be injurious.

37.

If the front coxæ are nearly as large as the thighs, it belongs to the Mantidæ.

The Mantidæ have a great number of common names. They feed on other insects, and their front legs are of peculiar shape to enable them to grasp their prey. The eggs are laid in a large mass on the side of a twig. They pass the winter in this stage.

If the front coxæ are small, it is one of the Phasmidæ.

The walking sticks, or Phasmidæ, feed on the leaves of plants. They are mostly wingless, and are very long and slender. The eggs are dropped singly on the ground, where they pass the winter.

38.

If the antennæ are much longer than the thorax, refer to 39.

If the antennæ are about as long as the thorax, it is one of the Acrididæ.

The Acrididæ, commonly called grasshoppers, are very destructive to vegetation. The eggs are laid in masses in holes in the ground. They generally pass the winter in this stage, but some pass the winter as nymphs or full-grown insects.

39.

If the feet have four joints, it is one of the Locustidæ.

The Locustidæ is the katydid family. They feed on the leaves of almost all kinds of plants. They generally pass the winter as eggs, which are laid about the plant in various places, according to the species.

If the feet have three joints, it is one of the Gryllidæ.

The Gryllidæ, or crickets, mostly live in the ground, but some live on the leaves of plants. They feed mostly on plants, but will eat other things. The eggs are laid in various places, according to the species.

SYNOPSIS OF THE FAMILIES OF PHYSOPODA.

The insects of this order are quite uniform in habit, sometimes doing considerable injury by their attacks on the flowers of grasses and forage plants. They are all very small, and pass the winter as full-grown insects. Their life history has not been well made out. Three families form this order, and may be told as follows:

40.

If the last joint of the abdomen is long, slender, and tube-like, it is one of the Tubuliferidæ.

This is a small family, but contains some rather common species.

If the last joint of the abdomen is not long, slender, and tube-like, refer to 41.

41.

If the borer of the female is bent down and the wings have no cross veins, it is one of the Stenopteridæ.

Most of the true thrips belong to this family.

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If the borer of the female is bent up and the wings have cross veins, it belongs to the Coleoptratidæ.

A very small family.

SYNOPSIS OF THE FAMILIES OF HEMIPTERA.

The Hemiptera are very distinct from other insects, and are a very important order. The following table will enable one to tell the families of both nymphs and full-grown insects:

42.

If the proboscis has but one joint, it is one of the Pediculidæ.

The Pediculidæ are the lice of man and other animals. They have a strong proboscis and live on blood. The eggs are attached to hairs. The young live in the same places, and have the same habits as the full-grown insects.

If the proboscis has more than one joint, or if there is none at all, refer to 43.

43.

If the proboscis seems to come from the middle of the breast, or if there is none at all, refer to 44.

If the proboscis plainly comes from the head, to 47.

44.

If the hind thighs are not much larger than the others, refer to 45.

If the hind thighs are very much larger than the others, it is one of the Psyllidæ.

The Psyllidæ is a small family of insects, resembling the plant lice. They live on plants, but are never abundant enough to do much injury.

45.

If the legs are short, or if there are none, refer to 46.

If the legs are long and slender, it belongs to the Aphidæ.

The family Aphidæ includes the plant lice. They do a great deal of injury, attacking the tender, growing parts of plants and sucking the sap. Eggs are generally laid in the fall, but during most of the year the young are brought forth alive.

46.

If the feet have one joint, or if there are none, it is one of the Coccidæ.

The Coccidæ, or scale insects, do a great amount of injury to the plants they infest, particularly trees. The body of most species is covered with a scale secreted by the insect. The eggs are laid beneath this scale. The young travel over the tree, but as they get larger they become fixed, and often lose their legs entirely. The males, when full grown, have a pair of wings.

If the feet have two joints, it belongs to the Aleyrodidæ.

The Aleyrodidæ is a small family of insects that, when young, resemble scale insects very much, but when full grown they all have wings. They are quite common insects, but never very abundant.

47.

If the cheeks touch the front coxæ, refer to 48.

If the cheeks do not touch the front coxæ, to 52.

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48.

If it has three ocelli, and if it has large front shanks and no wings, it is one of the Cicadidæ.

The Cicadidæ, or harvest flies, live in the ground, mostly on the roots of trees. The full-grown males are musical, and the females often do considerable injury in laying eggs in the twigs of trees.

If it has two ocelli, or none at all, and if the front shanks are not much enlarged, go to 49.

49.

If the antennæ are fastened to the head below the eyes, it belongs to the Fulgoridæ.

This family includes quite a number of quite common insects living on many kinds of plants, but never numerous enough to do much injury.

If the antennæ are fastened to the head in front of and between the eyes, refer to 50.

50.

If the prothorax reaches way back over the abdomen, it is one of the Membracidæ.

The insects of this family are often of very peculiar form. They feed on almost all kinds of plants, but never become very injurious.

If the prothorax does not reach back over the abdomen, refer to 51.

51.

If there are only a few spines on the hind shanks, it belongs to the Cercopidæ.

The young of many species of this family surround themselves with a watery substance, and are therefore called spittle insects. They are never very abundant.

If there are two rows of spines on the hind shanks, it is one of the Jassidæ.

The Jassidæ often become quite injurious, especially in meadows. The insect known as the grape thrip belongs here.

52.

If the antennæ are shorter than the head, refer to 53.
If the antennæ are at least as long as the head, to 58.

53.

If there are no ocelli, refer to 54.
If there are two ocelli on the head, it is one of the Galgulidæ.

The Galgulidæ is a small family of short, roundish insects, living on the muddy banks of streams.

54.

If there are no claws on the hind feet, refer to 55.
If there are claws on the hind feet, to 56.

55.

If the head overlaps the prothorax, it is one of the Corisidæ.

The Corisidæ are small bugs that live in the water and feed on other insects.

If the prothorax overlaps the head, it is one of the Notonectidæ.

The Notonectidæ are somewhat larger than the Corisidæ, but have much the same habits.

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56.

If there are two long tails on the abdomen, which fit together, forming a long, slender tube, it is one of the Nepidæ.

The Nepidæ live in the water and feed on other insects.

If there are any tails on the abdomen that are flat and can be drawn into the body, refer to 57.

57.

If the hind feet are broad and flat, it is one of the Belastomidæ.

The family Belastomidæ contains the largest insects in the order. They are flat-bodied insects which live in the water and feed on other insects. Some attack also young fish.

If the hind feet are slender, it is one of the Naucoridæ.

The Naucoridæ is a small family of flat-bodied water bugs that feed on other insects.

58.

If the head is as long as the whole thorax, it is one of the Limnobatidæ.

The Limnobatidæ are very slender insects, living and probably feeding on water plants.

If the head is shorter than the thorax, refer to 59.

59.

If the last joint of the foot is split and the claws are not at the end, refer to 60.

If the last joint of the foot is not split and the claws are at the end, to 61.

60.

If the middle and hind legs are very long, it is one of the Hydrobatidæ.

The Hydrobatidæ are rather slender, long-legged bugs, living on the surface of the water and feeding on other insects.

If the middle and hind legs are not very long, it is one of the Veliidæ.

The Veliidæ is a very small family of bugs, which live mostly on the surface of the water and feed on other insects.

61.

If the antennæ are three or four-jointed, refer to 62.

If the antennæ are five-jointed, to 74.

62.

If the proboscis has three joints, refer to 63.

If the proboscis has four joints, to 68.

63.

If the body is very long and slender, it is one of the Emesidæ.

The Emesidæ is a small family of very slender bugs, rather common in grass. They capture and eat other insects.

If the body is not long and slender, refer to 64.

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64.

If the front thighs are very wide, it is one of the Phymatidæ.

The Phymatidæ lie concealed in flowers, and capture and feed on other insects.

If the front thighs are not very wide, refer to 65.

65.

If the antennæ have three joints, it belongs to the Reduviidæ.

The Reduviidæ is a large family of bugs which feed on other insects.

If the antennæ have four joints, refer to 66.

66.

If the feet have two joints, it is one of the Aradidæ.

The Aradidæ are very flat bugs, found beneath the bark of logs. They are supposed to feed on fungi or on the decaying wood.

If the feet have three joints, refer to 67.

67.

If the insect is flat above, it is one of the Acanthiidæ.

The bedbug, which belongs to this family, never has wings; other members of the family, however, do have them, and these feed on other insects.

If the body is not flat above, it is one of the Saldidæ.

The Saldidæ is a small family of very active bugs, living on the ground, and probably feeding on other insects.

68.

If there are no ocelli on the head, refer to 69.

If there are ocelli on the head, to 70.

69.

If it is a heavy-bodied insect, it belongs to the Pyrrochoridæ.

The Pyrrochoridæ is a small family of rather large, heavy-bodied bugs, which feed on plants.

If it is a light-bodied insect, it is one of the Capsidæ.

The Capsidæ is one of the largest families of bugs. They all feed on plants and several are very destructive.

70.

If the front legs are very different from the rest, it is one of the Nabidæ.

The Nabidæ feed on other insects. Their front is so made as to enable them to capture their prey.

If the front legs are not very different from the others, refer to 71.

71.

If the body is very narrow, it is one of the Berytidæ.

The Berytidæ is a small family of very long, slender insects, and though they feed on plants they are never numerous enough to do any injury.

If the body is not very slender, refer to 72.

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72.

If the feet have two joints, it belongs to the Tingitidæ.

These insects are remarkable for their wide, flattened shape. They are rather common, but never numerous enough to do any damage.

If the feet have three joints, refer to 73.

73.

If the antennæ are fastened to the head below a line drawn from the eye to the proboscis, it is one of the Lygæidæ.

The Lygæidæ is one of the largest families of bugs, and contain a number of injurious species. The chinch bug of the Eastern States belongs here.

If the antennæ are fastened to the head above a line drawn from the eye to the proboscis, it belongs to the Coreidæ.

The Coreidæ is one of the most extensive families of bugs, and contain a number of injurious species. Some others feed on other insects.

74.

If the body is flat above, refer to 75.
If the body is not flat above, to 76.

75.

If there are few or no spines on the shanks, it is one of the Pentatomidæ.

The Pentatomidæ is a rather important family of bugs. Some do a great deal of injury to plants, while others feed on other insects and are beneficial. The same species may even eat both animal and vegetable food.

If there are rows of spines on the shanks, it belongs to the Cydnidæ.

The insects of this family live near the ground or beneath the surface. They probably feed on plants, but do no injury.

76.

If the prothorax is round in front and nearly straight behind, it is one of the Corimelænidæ.

The Corimelænidæ sometimes become quite injurious, both by their attacks on the leaves of plants and on the berries of small fruit.

If the prothorax is six-sided, it belongs to the Scutelleridæ.

The Scutelleridæ are a rather small family of bugs, which feed on plants, but have never been numerous enough to be destructive.

SYNOPSIS OF THE FAMILIES OF COLEOPTERA.

The order Coleoptera comprises the largest and most important group of insects. The earlier stages of comparatively few of the species are known, so it is impossible to make a synopsis for any but the full-grown insect.

77.

If the hind feet have four joints and the others five, refer to 78.
If the hind feet have as many joints as the others, to 93.

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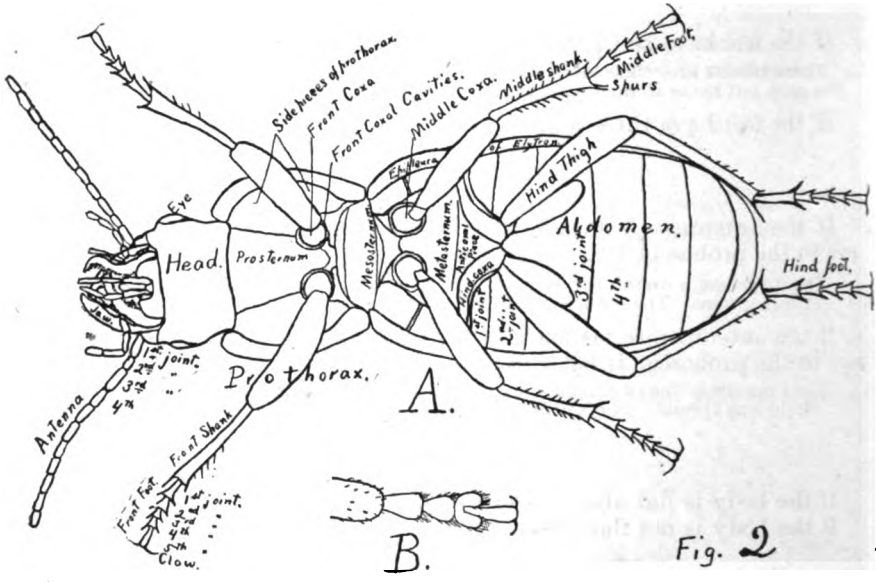

Fig. 2

78.

If the mesosternum forms part of the boundary of the front coxal cavities, refer to 79.

If the mesosternum does not form a part of the boundary of the front coxal cavities, to 88.

79.

If there is a neck between the head and body, refer to 80.

If there is no neck between the head and body, to 85.

80.

If the head is suddenly narrowed into a neck, refer to 81.

If the head goes gradually into a neck, it is one of the Cephaloidæ.

The Cephaloidæ is a small family of rare insects, the habits of which are not well known.

81.

If the prothorax is as wide as the rest of the body where they join, refer to 82.

If the prothorax is narrower than the rest of the body where they join, to 83.

82.

If the antennæ are thread-like, it is one of the Mordellidæ, unless the elytra cover all the abdomen, when it is one of the Melandridæ; or, unless the eyes are large, when it is one of the Rhipiphoridæ.

The Mordellidæ are found on flowers, and are quite common. The young probably feed on rotting stumps, etc.

If the antennæ are saw-like or comb-like, it belongs to the Rhipiphoridæ.

The larvæ of the Rhipiphoridæ probably all live parasitically on various other insects. The full-grown beetles are found on flowers.

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83.

If the hind coxæ are large, refer to 84.

If the hind coxæ are not very large, it is one of the Anthicidæ.

The habits of these beetles are not well understood. One species in this State occasionally does considerable injury by eating into apples. They are found in all sorts of situations. The young are not known.

84.

If the mouth is in front of the head, it is one of the Pyrochoridæ.

This a small family of beetles found under the bark of decaying logs and stumps.

If the mouth is below the head, it is one of the Meloidæ.

The Meloidæ form an important family of beetles, known as blister beetles, as they are used in medicine for that purpose. They eat the leaves of many kinds of plants, and do much injury. The young go through a most remarkable course of development. The youngest stage lives parasitically on other insects.

85.

If the middle coxæ are large, it is one of the Œdemeridæ.

The Œdemeridæ is a small family of beetles, found as a rule on plants, but whose habits and life histories are not well known.

If the middle coxæ are not very large, refer to 86.

86.

If the antennæ lie in grooves, it is one of the Monomidæ, unless they are bent like an elbow, when it is one of the Histeridæ.

The Monomidæ is a very small family of beetles, whose habits are not well known.

If the antennæ do not lie in grooves, refer to 87.

87.

If the prothorax has a sharp edge it is one of the Melandridæ, unless—

(*a*) The antennæ has three, and only three, joints at the end, much larger than the others, when it is one of the Cryptophagidæ; or unless,

(*b*) The front coxæ are small, when it is one of the Cucujidæ; or unless,

(*c*) It belongs to neither of these two families, and has the prothorax nearly square, when it is one of the Pythidæ.

The Melandridæ are found quite commonly under bark, in fungi and such situations.

If the prothorax has no sharp edge, it is one of the Pythidæ, unless—

(*a*) The antennæ have three, and only three, joints at the end, much larger than the others, when it is one of the Cryptophagidæ; or unless,

(*b*) The metasternum is nearly square, when it is one of the Cucujidæ.

The Pythidæ is a small family of quite rare insects, whose habits are not well known.

88.

If the claws on the feet are not comb-like, refer to 89.

If the claws on the feet are comb-like, it is one of the Cistellidæ.

The Cistellidæ live under bark, and also on plants. The habits are not well known.

89.

If the abdomen has five joints beneath, refer to 90.

If the abdomen has six joints beneath, it belongs to the Ægialitidæ, unless the front coxæ are close together, when it is one of the Silphidæ.

The Ægialitidæ is a small family of rare insects, whose habits are not known.

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90.

If some of the joints of the abdomen are glued together, refer to 92.
If all of the joints of the abdomen are movable, to 91.

91.

If the front coxæ are so close that they touch each other, it is one of the Othniidæ.

The Othniidæ are supposed to feed on other insects, but their habits are not well known. It contains only a small number of rare insects.

If the front coxæ do not touch each other, it belongs to the Sphindidæ, unless the front coxæ are round, when it is of the Cucujidæ, or unless the metasterum is short, when it is one of the Nitidulidæ.

The Sphindidæ is a small family of fungus-eating beetles, attacking chiefly woody fungi.

92.

If the next to the last joint of the foot is not spongy beneath, it is one of the Tenebrionidæ.

The Tenebrionidæ is a large family of beetles which feed on decaying vegetable substances.

If the next to the last joint of the foot is spongy beneath, it is one of the Lagriidæ.

This is a small family that live under bark on logs and are also found on leaves of plants, but their habits are not known.

93.

If the slender piece at the end of the foot is fastened in between the divided third joint, refer to 94.
If the third joint is not divided, or when it is, if the rest of the foot is not a single slender piece, to 104.

94.

If there are spurs at the end of the shanks, refer to 101.
If there are no spurs at the end of the shanks, to 95.

95.

If the shanks are saw-like on the inner side, refer to 96.
If the shanks are smooth on the inner side, to 97.

96.

If there is a fold on the inner edge of the elytra, it belongs to the Scolytidæ.

This large family of beetles are small and more or less cylindrical insects. They are very destructive to trees, boring mostly just beneath the bark, where they may be found in all stages. The larvæ are footless and slightly curved.

If there is no fold on the inner edge of the elytra, it is one of the Attelabidæ.

A very small family, whose habits are not well known.

97.

If the antennæ are bent like an elbow, refer to 98.
If the antennæ are not bent like an elbow, to 100.

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98.

If there is a scar at the end of the jaw, showing where a piece has come off, it belongs to the Otiorhynchidæ.

The Otiorhynchidæ is a large family of weevils, attacking the plant in almost every part during their life as larvæ, and, like other weevils, then change to full-grown insects within their burrows.

If there is no scar at the end of the jaw, refer to 99.

99.

If the first joint of the large part of the antennæ is smooth and shining, it is one of the Calandridæ.

The Calandridæ is a rather large family of beetles, living in the larva stage mostly in the stems of plants, while a few attack stored grain. They often do considerable injury.

If none of the large part of the antennæ is smooth and shining, it belongs to the Curculionidæ.

This is the largest family of weevils, and contains many of the most destructive species. The larvæ attack every part of the plant. The fruit weevils are perhaps the best known.

100.

If there is a snout on the head, it is one of the Anthribidæ, unless it is short or unless the front coxæ touch each other, when it is one of the Curculionidæ.

The Anthribidæ are weevils, which, in the larva stage, live in the seeds and stems of plants. Some are footless and some have six legs. The larva of one species has been found beneath the scales of bark lice, and is supposed to feed on them.

If there is no snout on the head, it is one of the Bruchidæ, unless the first three joints of the foot are brush-like beneath, when, if the insect is three times as long as wide, it is one of the Erotylidæ; if not three times as long as broad, it is one of the Chrysomelidæ.

The Bruchidæ is a small family, including the pea and bean weevils. The other species live in seeds of the pea family.

101.

If the claws on the feet are double pointed, it is one of the Rhynchitidæ, unless the eyes are not round, when it is one of the Cerambycidæ, or unless the elytra have a strong fold on the inner side, when it is one of the Curculionidæ.

The Rhynchitidæ is a small family of weevils, the habits of which are not well known.

If the claws on the feet are single pointed, refer to 102.

102.

If there is a fold on the inner edge of the elytra, it is one of the Brenthidæ, unless the metasternum is short, when it is one of the Otiorhynchidæ.

The Brenthidæ is a small family of weevils, whose larvæ bore into trees. The larvæ are long, slender, and footless.

If there is no fold on the inner edge of the wing, refer to 103.

103.

If there is a long snout on the head, it belongs to the Rhinomaceridæ.

The Rhinomaceridæ lay their eggs in the flowers of the pine trees, upon which the larvæ feed. It is a very small family.

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If there is no long snout on the head, it is one of the Chrysomelidæ, unless there is no brush of hairs beneath, when it belongs to the Spondylidæ.

The Chrysomelidæ is one of the largest and most important families of beetles. They feed generally on the leaves of plants, both as larvæ and full-grown insects, but the larvæ of some bore into the leaves, stems, or roots of plants. Some change to pupæ where they feed; others enter the ground, and a few spin cocoons.

104.

If the first joint of the abdomen is divided beneath by the hind coxæ, refer to 151.

If the first joint of the abdomen is not divided beneath by the hind coxæ, to 105.

105.

If the last few joints of the antenna are long and fastened together at one end so as to form a comb-like club, refer to 106.

If the antenna does not end in a comb-like club, to 107.

106.

If the teeth of the club of the antennæ cannot be closed tightly together, it is one of the Lucanidæ.

The larvæ of the Lucanidæ live in decaying logs, and the adult insects can be found in the same localities, though only a part of them feed in this stage. Most of the insects of this family are quite large.

If the teeth of the club can be closed tightly together, it is one of the Scarabæidæ.

Many of the full-grown insects of this family injure plants to a considerable extent by eating the buds and leaves. The larvæ live in the ground on the roots of plants or in dung.

107.

If the body is long and not covered by the wings, refer to 150.

If the body is not long, or if it is at least half covered by the wings, to 108.

108.

If the front feet have five joints, refer to 121.

If the front feet have three or four joints, to 109.

109.

If the abdomen has six or seven joints beneath, refer to 110.

If the abdomen has five joints beneath, to 113.

If the abdomen has three joints beneath, it is one of the Sphæriidæ.

A very small family of beetles, whose habits are not well known.

110.

If all the joints of the abdomen are about the same length, refer to 111.

If the first and sixth joints of the abdomen are each longer than the other four together, it belongs to the Hydroscaphidæ.

The family of Hydroscaphidæ includes a single species, which is a very small insect living in the water.

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111.

If there are claws on the feet, refer to 112.

If there are no claws on the feet, it is one of the Stylopidæ.

The Stylopidæ is a small family of very remarkable beetles. The young live as parasites in the bodies of various bees and wasps.

112.

If the third joint of the foot is fastened to the end of the second joint, it is one of the Trichopterygidæ, unless the feet have four joints, when it is one of the Silphidæ.

The Trichopterygidæ are the smallest insects in the order. Their habits are not known.

If the third joint is fastened in between the divided parts of the second joint, it is one of the Corylophidæ, unless the front coxæ are wide, when it is one of the Coccinellidæ.

The Corylophidæ are small insects, whose habits are not known.

113.

If the antennæ are fastened to the head beneath a sharp edge, refer to 119.

If the antennæ are not fastened to the head beneath a sharp edge, to 114.

114.

If the feet have three joints, refer to 115.

If the feet have four joints, to 117.

115.

If the front coxæ are broad, it is one of the Coccinellidæ.

These insects feed almost exclusively on plant lice and scale insects, and are among our most useful insect friends. The eggs are laid on the leaves and stems of plants, and the young larvæ, which have six legs, feed on the lice. When full grown they fasten the end of the abdomen to the plant, and then change to pupæ, and finally to full-grown beetles.

If the front coxæ are round, refer to 116.

116.

If the mesosternum forms part of the boundary of the front coxal cavity, it is one of the Endomychidæ.

This small family includes some of the beetles that feed on fungi, both as larvæ and as full-grown insects.

If the mesosternum does not form a part of the boundary of the front coxal cavities, it is one of the Lathrididæ, unless only the front feet have three joints, when it is one of the Mycetophagidæ.

The Lathrididæ is a small family of insects, feeding mostly on fungi.

117.

If all the joints of the abdomen are movable, refer to 118.

If the first two joints are glued together, it is one of the Byrsopidæ, unless the feet are like a brush, when it is one of the three families

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Otiorhynchidæ, Curculionidæ, or Calandridæ. For telling these apart, refer to 98.

The Byrsopidæ is a small family of weevils, some of which attack plants, but are not injurious.

If all but the last joint of the abdomen are glued together, it is one of the Heteroceridæ.

The Heteroceridæ are quite common in wet sand along the banks of streams. There are only a few species, and their food is not known.

118.

If the mesosterum forms part of the boundary of the front coxal cavities, it is one of the Mycetophagidæ, unless the coxæ are round, when, if the feet are slender, it is one of the Endomychidæ, and if they are broad and spongy beneath, it belongs to the Erotylidæ.

The Mycetophagidæ is a family of small insects, feeding mostly on fungi.

If the mesosterum does not form a part of the boundary of the front coxal cavities, it is one of the Cioidæ.

The Cioidæ is a small family of beetles, found under bark and in woody fungi.

119.

If the prosternum is very small, it is one of the Georyssidæ.

This is a very small family of beetles, whose habits are not known.

If the prosternum is not very small, refer to 120.

120.

If the elytra do not cover all the abdomen, it belongs to the Monotomidæ.

The Monotomidæ are small, flattened beetles, found under bark.

If the elytra cover the abdomen, it is one of the Colydiidæ, unless the front coxæ are broad, when, if the metasterum is short, it is one of the Nitidulidæ, or if it is large, it belongs to the Coccinellidæ.

The Colydiidæ are small insects, probably feeding on fungi, but whose habits are not well known.

121.

If the fourth joint of the foot is very short, refer to 122.
If the fourth joint of the foot is not small, to 123.

122.

If the feet are not brush-like beneath, it is one of the Spondylidæ, unless it is a very small insect, less than a quarter of an inch in length, when, if the fourth joint of the foot is as long as the third, it is one of the Dermestidæ; if shorter, it is one of the Mycetophagidæ.

The Spondylidæ is a small family of wood-borers, living in decaying logs and stumps.

If the feet are brush-like beneath, it belongs to the Cerambycidæ, unless the first joint of the abdomen is as long as all the others together, when it is one of the Chrysomelidæ.

The Cerambycidæ is a very large family of wood-borers, living in decaying wood and also attacking living trees. The eggs are laid on the bark, and the young larva, as soon as hatched, proceeds to burrow into the tree.

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123.

If the front coxæ are broad, refer to 143.
If the front coxæ are round, to 124.

124.

If the thighs fit into hollows in the hind coxæ, refer to 139.
If there are no hollows in the hind coxæ, to 125.

125.

If the antennæ are fastened to the head beneath a sharp edge, refer to 133.
If the antennæ are not fastened to the head beneath a sharp edge, to 126.

126.

If the front coxæ are very close together, refer to 127.
If the front coxæ are wide apart, to 131.

127.

If the fifth joint of the abdomen is very large, it is one of the Scaphididæ.

The Scaphididæ is a very small family of small insects, which feed on fungi.

If the fifth joint of the abdomen is not very large, refer to 128.

128.

If the abdomen has seven or eight joints, it is one of the Lampyridæ.

The Lampyridæ feed on other insects. They live in the ground while larvæ, and perhaps may also eat the roots of the plants. Some species have the power of giving out light.

If the abdomen has five or six joints, refer to 129.

129.

If the hind coxæ are flat, it is one of the Cleridæ, unless it is a flattened, oval insect, when it belongs to the Silphidæ.

The full-grown Cleridæ are found on plants, but their food is not known. The young feed on other insects as a rule, but a few attack decaying animal matter.

If the hind coxæ are not flat, refer to 130.

130.

If the metasternum is long, it is one of the Lymexylidæ, unless the mesosternum is also long, when it belongs to the Scydmænidæ.

The Lymexylidæ are wood-borers when larvæ, but being a small family and rather rare, they are of no economic importance.

If the metasternum is short, it is one of the Malachiidæ.

The Melachiidæ are small beetles that feed on other insects. The larvæ are not known.

131.

If all the joints of the abdomen are about the same length, refer to 132.
If the first joint of the abdomen is longer than the others, it is one of the Cryptophagidæ.

The Cryptophagidæ are small insects, feeding mostly on fungi.

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132.

If the mesosternum forms part of the boundary of the front coxal cavity, it is one of the Cucujidæ.

The Cucujidæ is a family of flattened beetles, living mostly under bark. One species does a good deal of injury, feeding on grain.

If the mesosternum does not form a part of the boundary of the front coxal cavity, it is one of the Erotylidæ.

Most of the insects belonging to this small family live in fungi, but some are very injurious to clover in the Eastern States.

133.

If the antennæ have six to nine joints, it is one of the Hydrophilidæ.

The insects of this family live mostly in the water. The young feed on other insects, but the full-grown beetles live mostly on decaying matter.

If the antennæ are eleven-jointed, refer to 134.

134.

If the metasternum is shorter than the mesosternum, it is one of the Leptidæ.

The Leptidæ is a small family of beetles found about the nests of small animals upon which they are supposed to be parasitic.

If the metasternum is longer than the mesosternum, refer to 135.

135.

If the first three joints of the abdomen beneath are glued together, it is one of the Rhyssodidæ.

A small family of insects living under bark.

If all the joints of the abdomen are movable, refer to 136.

136.

If the prosternum reaches back and fits into the edge of the mesosternum, it is one of the Phalacridæ.

The Phalacridæ is a very small family of insects found on flowers and in other places, but whose habits are not known.

If the prosternum does not reach back toward the mesosternum, refer to 137.

137.

If the abdomen has six joints beneath, refer to 138.

If the abdomen has five joints beneath, it is one of the Ptinidæ, unless the mesosternum does not form part of the boundary of the front coxal cavity, when it is one of the Silphidæ.

The Ptinidæ live on dead or decaying vegetable substances, and some do considerable injury to food products.

138.

If the hind coxæ do not touch each other, it is one of the Scydmænidæ, unless the eyes are very small or none at all, when it is one of the Silphidæ.

The Scydmænidæ are small insects found in many situations, but whose habits are not well known.

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If the hind coxæ touch each other, it is one of the Silphidæ, unless there are ocelli, when it belongs to the Staphylinidæ.

The Silphidæ feed on decaying substances, and are the common beetles found on carrion. The small species attack fungi and decaying vegetable substances.

139.

If the antennæ are large at the end, it is one of the Dermestidæ, unless the legs are long, when it is one of the Parnidæ.

The insects of the family Dermestidæ generally live on dried animal remains, injuring pelts and furs to a great extent. Some attack plants, and one species in the State has done good service in destroying the egg masses of the Orgyia.

If the antennæ are not large at the end, refer to 140.

140.

If the first two joints of the abdomen beneath are glued together, it is one of the Buprestidæ.

The larvæ of Buprestidæ live in burrows in plants, and they are often very injurious. The full-grown insect is often found on flowers.

If all the joints of the abdomen are movable, refer to 141.

141.

If the prosternum reaches back and fits into the edge of the mesosternum, refer to 142.

If the prosternum does not reach back toward the mesosternum, it is one of the Rhipiceridæ, unless the first joint of the foot is small, when it is one of the Ptinidæ.

The larvæ of the Rhipiceridæ bore into trees, and when abundant may do considerable injury. There are only a few species in the family.

142.

If the mesosternum forms a part of the boundary of the front coxal cavities, it is one of the Throscidæ.

The Throscidæ is a small family of beetles found on flowers. Their habits are not known.

If the mesosternum does not form a part of the boundary of the front coxal cavities, it is one of the Elateridæ.

The Elateridæ is a large family of very injurious insects. The larvæ, known as wireworms, live in the ground, attacking the roots of all kinds of plants.

143.

If the hind coxæ are broad, refer to 144.

If the hind coxæ are round, it is one of the Histeridæ.

The Histeridæ is a family of short, very hard-bodied beetles, which are generally shining black. They probably all feed on fungi or decaying vegetable matter.

144.

If the thighs fit into hollows in the hind coxæ, refer to 146.

If there are no hollows in the hind coxæ, to 145.

145.

If the feet are wide, it is one of the Nitidulidæ.

The Nitidulidæ live on decaying vegetable substances; a few attack overripe fruit.

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If the feet are slender it is one of the Trogositidæ, unless the elytra do not cover all the abdomen, when it is one of the Silphidæ.

The Trogositidæ are mostly found under the bark of logs, but some species attack stored grain, and do considerable injury.

146.

If the mesosternum forms a part of the boundary of the front coxal cavities, refer to 147.

If the mesosternum does not form a part of the boundary of the front coxal cavities, it is one of the Derodontidæ.

A small family of beetles, whose habits are not known.

147.

If the prosternum reaches back and fits into the edge of the mesosternum, refer to 149.

If the prosternum does not reach back toward the mesosternum, to 148.

148.

If the first two or three joints of the abdomen are glued together, it is one of the Parnidæ.

Some of the Parnidæ live in the water and some on land. Their food is probably decaying vegetable matter.

If all the joints of the abdomen are movable, it is one of the Dascyllidæ.

The Dascyllidæ live on plants near the water, but are never very abundant.

149.

If the epipleuræ reach to the end of the elytra, it belongs to the Cupesidæ.

The Cupesidæ is a small family of rare insects. The larvæ are borers, but probably do not attack living trees.

If the epipleuræ do not reach the end of the elytra, it is one of the Byrridæ.

The Byrridæ is a small family of rather rare insects, found under stones and the bark of logs. Their habits are not known.

150.

If the abdomen has seven or eight joints beneath, it is one of the Staphylinidæ, unless the elytra are pointed behind, when it is one of the Lampyridæ.

The Staphylinidæ is a very extensive family of beetles. They are mostly of small size. They feed on decaying vegetable substances.

If the abdomen has five or six segments beneath, it is one of the Pselaphidæ.

The Pselaphidæ is quite an extensive family of very small insects, found in various situations. Their habits are probably the same as the Staphylinidæ.

151.

If the metasternum has a distinct antecoxal piece, refer to 154.

If the metasternum has a very short antecoxal piece, it is one of the Amphizoidæ.

The Amphizoidæ is a small family of rare insects. The full-grown insects are found under stones in the water.

If the metasternum has no antecoxal piece, to 152.

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152.

If the elytra cover all the abdomen, refer to 153.

If the elytra do not cover all the abdomen, it belongs to the Platypsylidæ.

The family of Platypsylidæ contains a single species, which is parasitic on the beaver.

153.

If the head has two eyes, it is one of the Dytiscidæ.

The Dytiscidæ is a rather extensive family of water beetles. Both the larvæ and the full-grown beetles feed on other water insects.

If the head has four eyes, it belongs to the Gyrinidæ.

This is a small family, but the insects are quite common. The larvæ live in the water, and the full-grown insects swim mostly on the surface. They feed on other insects.

154.

If the antennæ have eleven joints, refer to 155.

If the antennæ have ten joints, it is one of the Haliplidæ.

The Haliplidæ live in and near the water. It is a small family, the habits of which are not well known.

155.

If the antennæ are fastened to the front of the head, it is one of the Cicindelidæ.

The species belonging to this family feed on other insects, both as larvæ and full-grown insects. The larvæ live in holes in the ground.

If the antennæ are fastened to the sides of the head, it is one of the Carabidæ.

The Carabidæ is one of the largest families of beetles. They feed mostly on other insects, but a few have been known to attack plants. The larvæ, as well as the full-grown insects, live in the ground. They may be found quite abundantly under stones.

SYNOPSIS OF THE FAMILIES OF NEUROPTERA.

This order contains no injurious species. Only the adult insects may be divided into families by this synopsis, as the larva and pupa stages are not well enough known to be included.

156.

If the mouth is at the end of a long trunk, it is one of the Panorpidæ.

The Panorpidæ generally have four wings. These are equal in size and are often quite prettily colored. The food habits are not well known.

If the mouth is not at the end of a trunk, refer to 157.

157.

If the prothorax is small, refer to 158.

If the prothorax is large, it belongs to the Sialidæ.

The larvæ of the Sialidæ live in the water, feeding on other insects. They have gills on the sides, and the full-grown insect is of rather large size.

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158.

If all the wings are alike, it is one of the Hemerobidæ.

The Hemerobidæ live on plants or in the ground and feed on other insects. The lace-wing flies are the only ones that are very beneficial.

If the front wings are not like the hind wings, or if there are no wings at all, the insect belongs to the Phryganæidæ.

The Phryganæidæ live in the water in cases, which they make of sticks and stones, and such things. The full-grown insects are attracted to lights, and resemble moths.

SYNOPSIS OF THE FAMILIES OF LEPIDOPTERA.

Almost all the Lepidoptera feed on plants in the larva stage, and as full-grown insects they are not injurious. The classification of the moths is in an almost unsatisfactory condition. The synopsis below will enable the student to place most of the species correctly. It is, however, confessedly inaccurate for many species. At present it is impossible to make a synopsis for the larvæ or pupæ.

159.

If the end of the antenna is much thickened, refer to 160.

If the end of the antenna is not thickened, to 163.

160.

If the antennæ are close together where they are fastened to the head, refer to 161.

If the antennæ are far apart where they are fastened to the head, it is one of the Hesperidæ.

These are small, heavy-bodied butterflies. None of the larvæ have become injurious to useful plants.

161.

If the front legs are like the others, and have claws, refer to 162.

If the front legs are small, and there are no claws on the feet, it is one of the Nymphalidæ.

All the larger brownish butterflies belong here. The larvæ of very few attack useful plants, and these are seldom numerous enough to do any injury.

162.

If the face between the eyes is very narrow, it is one of the Lycænidæ.

This family includes the smallest and most delicate of the butterflies. They are not injurious.

If the face is about as broad as high, it is one of the Papilionidæ.

The Papilionidæ include the large black and yellow, and small white and yellow, butterflies. The larvæ of the white butterflies are the only ones that have proven very injurious.

163.

If each of the wings is split into two or three long, slender pieces, it is one of the Pterophoridæ.

The Pterophoridæ is a small family known as plume moths, on account of their plume-like appearance, due to the splitting of the wings. The larvæ feed within folded leaves. They never do much injury.

If the wings are not split, refer to 164.

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164.

If the insect is very small and the hind wings are very narrow, it is one of the Tineidæ.

The Tineidæ is a rather large family, and include the smallest insects of the order. The larvæ of many of them burrow into leaves, eating out the green parts. Some species do considerable damage to clothing, stored grain, etc.

If this is not the case, refer to 165.

165.

If the body is thick, and more than half an inch long, and the hind wings are very narrow, it is one of the Sphingidæ.

The larvæ of the Sphingidæ almost always have a horn on the hind end of the body. They are large worms, and often do much injury. Some spin a cocoon, and others go into the ground to change to pupæ.

If this is not the case, refer to 166.

166.

If it is slender, about a half an inch long, with the wings slender and only partly covered with scales, it is one of the Ægeridæ.

The Ægeridæ are small moths, having a general resemblance to wasps. The larvæ bore into the stems of plants, some attacking trees. They are all quite destructive.

If this is not the case, refer to 167.

167.

If the front and hind edges of the front wings keep about the same distance apart for nearly the whole length of the wing, it is one of the Tortricidæ.

The Tortricidæ when larvæ roll up leaves, in which they live and feed. They are small insects, but many do a good deal of injury.

If the front wing keeps getting wider toward the outer end, refer to 168.

168.

If the front wings are narrow and the hind wings broad, and the antennæ slender and not thickened anywhere, it is one of the Pyralidæ.

The Pyralidæ have much the same habits as the Tortricidæ, but there are few species that are injurious.

If this is not the case, refer to 169.

169.

If the outer edge of the wing is bent at one or more places, it is one of the Geometridæ.

The larvæ of the Geometridæ are the well-known measuring worms. There are a great number of species, and some do considerable injury.

If the outer edge of the wing is an even curve, refer to 170.

170.

If the head is not close to the body and the antennæ are thickened at the middle or toward the end, it is one of the Zygænidæ.

The Zygænidæ is a small family. A few of the species are injurious.

If this is not the case, refer to 171.

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171.

If the antennæ are plume-like, it is one of the Bombycidæ.

The Bombycidæ is a large family, and includes quite a lot of injurious species. They nearly all spin a cocoon when ready to change to pupæ.

If the antennæ are slender and not plume-like, it is one of the Noctuidæ.

The Noctuidæ is the largest family of Lepidoptera, and includes the most destructive species. The cut-worms are the best known. When ready to change to pupæ they generally enter the ground.

SYNOPSIS OF THE FAMILIES OF DIPTERA.

The larva of Diptera is, with the exception of the blood-sucking species, the only stage in which flies are useful or injurious. This stage is known of comparatively few flies. The following synopsis, therefore, includes only the full-grown insects:

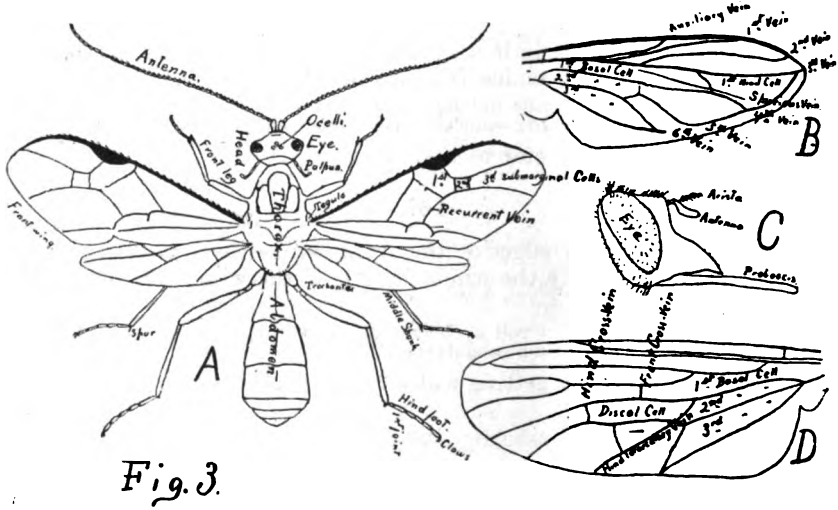

Fig. 3.

172.

If the insect is flat and stands edgewise, it is one of the Pulicidæ.

The Pulicidæ, or fleas, are entirely wingless. They attack the higher animals. The larvæ live in the ground.

If the insect does not stand edgewise, refer to 173.

173.

If the head is sunken into the thorax, it is one of the Hippoboscidæ.

The Hippoboscidæ live on birds and other animals. Some have no wings. The larva stage is passed within the body of the mother.

If the head is folded over into a groove on the back, it belongs to the Nycteribidæ.

The Nycteribidæ are very peculiar flies, without wings. They live on mice and other small animals. The larvæ live within the body of the mother.

If the head is fastened to the body by a neck in the ordinary manner, refer to 174.

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174.

If the joints of the antennæ are few, refer to 175.
If there are many joints to the antennæ, to 222.

175.

If the wings have several very stout veins near the front edge, and the rest of the veins are very weak, it is one of the Phoridæ.

The larvæ of the Phoridæ live in the bodies of other insects, and also in decaying substances.

If there is not this difference between the size of the veins, refer to 176.

176.

If there are only two pads between the claws, refer to 177.
If there are three pads between the claws, to 216.

177.

If there is no hind intercalary vein, refer to 178.
If there is a hind intercalary vein, to 213.

178.

If the arista is fastened to the side of the third joint of the antennæ, refer to 179.
If the arista is fastened to the end of the third joint of the antennæ, or if there is none, to 208.

179.

If there is a spurious vein, it is one of the Syrphidæ.

The Syrphidæ is one of the largest families of flies. Most of the larvæ feed on plant lice, and they are among our most useful insects. The full-grown flies are found on flowers.

If there is no spurious vein, refer to 180.

180.

If there is a large white scale on the thorax beneath the wing, refer to 203.
If there is no large scale beneath the wing, to 181.

181.

If the proboscis is horny, it is one of the Conopidæ, unless there are many bristles above the mouth, when it is one of the Cordyluridæ.

The Conopidæ look very much like wasps. The larvæ live parasitically in other insects.

If the proboscis is not horny, refer to 182.

182.

If the front border of the mouth has long bristles, refer to 195.
If the front border of the mouth has no long bristles, to 183.

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183.

If the first basal cell is absent, it is one of the Diopsidæ.

The habits of the Diopsidæ are not known.

If the first basal cell is present, refer to 184.

184.

If the third basal cell is large, refer to 189.

If the third basal cell is small or absent, to 185.

185.

If there is no auxiliary vein, refer to 186.

If there is an auxiliary vein, to 188.

186.

If the second basal cell is united with the discal, refer to 187.

If the second basal cell is small, but distinct from the discal, it belongs to the Opomyzidæ.

The habits of the Opomyzidæ are not known.

187.

If there are no bristles on the front of the head, unless there be a few at the top, it is one of the Oscinidæ.

The larvæ of the Oscinidæ live on plants, especially on grains and grasses. They are sometimes injurious.

If there are bristles on at least the upper half of the front of the head, it is one of the Ephydrinidæ.

The habits of the Ephydrinidæ are not well known.

188.

If the shanks near their tip have a small spur jointed to it, it is one of the Sapromyzidæ.

The young of the Sapromyzidæ live in decaying vegetable substances.

If the shanks do not have such spurs, it is one of the Lonchæidæ.

The young of the Lonchæidæ produce galls on plants, in which they live.

189.

If there is a spur near the end of the hind shank, it is one of the Sciomyzidæ.

The young of the family Sciomyzidæ are not known.

If there is no spur near the end of the hind shank, refer to 190.

190.

If the auxiliary vein runs steeply into the front margin of the wing, it is one of the Trypetidæ.

The larvæ of the Trypetidæ live on plants, sometimes becoming quite injurious.

If the auxiliary vein does not run steeply into the margin of the wing, go to 192.

If there is no auxiliary vein, refer to 191.

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191.

If the third basal cell reaches nearly to the edge of the wing, it is one of the Pipiculidæ.

The Pipiculidæ is a small family of parasitic flies.

If the third basal cell does not reach near to the edge of the wing, it is one of the Psilidæ.

The larvæ of the Psilidæ attack various plants, but have never done serious injury.

192.

If the legs are long, refer to 193.
If the legs are not long, to 194.

193.

If the first hind cell is almost closed, it is one of the Micropezidæ.

The habits of the Micropezidæ are not known.

If the first hind cell is not at all closed, it is one of the Sepsidæ.

The Sepsidæ live, when young, in decaying substances.

194.

If there are bristles on the lower part of the front of the head, it is one of the Phycodromidæ.

The habits of these insects are not known.

If there are no bristles on the lower part of the front of the head, it is one of the Ortalidæ.

The habits of the family Ortalidæ are not well known.

195.

If there is no auxiliary vein, refer to 196.
If there is an auxilary vein, to 201.

196.

If the first joint of the hind foot is shorter than the others, it is one of the Borboridæ.

The larvæ of the Borboridæ live in dung and other decaying substances.

If the first joint of the hind foot is longer than the others, refer to 197.

197.

If the hind cross vein is between the body and the middle of the wing, it is one of the Agromyzidæ.

Some of the Agromyzidæ live, when larvæ, on plants, and others feed on other insects.

If the hind cross vein is at or beyond the middle of the wing, refer to 198.
If there is no hind cross vein, to 200.

198.

If there are no bristles on the front of the head, though there may be a few at the top, it belongs to the Piophilidæ.

The worms often found in cheese belong to the Piophilidæ. The habits of the other kinds are not known.

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If there are bristles over the upper half of the front of the head at least, refer to 199.

199.

If the arista of the antennæ is like a feather, it is one of the Drosophilidæ.

The young of the Drosophilidæ live in many substances, but especially rotting fruit and fungi. They do not attack living plants.

If the arista of the antennæ is thickly covered with very short hair, or if it is like a bristle, it is one of the Geomyzidæ, unless there is no third basal cell, when it is one of the Ephydridæ.

The habits of the Geomyzidæ are not well known.

200.

If the arista of the antennæ is like a feather, it is one of the Asteidæ.

The habits of the Asteidæ are not known.

If the arista of the antennæ is thickly covered with very short hair, or if it is like a bristle, it is one of the Phytomyzidæ.

The larvæ of this family attack plants, but never do much injury.

201.

If the distance between the cross veins is very small, not more than a fourth as much as to the edge of the wing, it is one of the Heteroneuridæ.

The larvæ of the Heteroneuridæ have been found under the bark of decaying logs.

If the distance between the cross veins is but little less than the distance from the cross vein to the edge of the wing, refer to 202.

202.

If the lower part of the front of the head is bristly, it is one of the Cordyluridæ.

The young of the Cordyluridæ are probably parasitic on other insects, but the habits are not well known.

If the lower part of the front of the head is not bristly, it is one of the Helomoyzidæ.

The larvæ of the Helomoyzidæ have been found in dung and in decaying fungi.

203.

If there is no proboscis, it is one of the Œstridæ.

The Œstridæ are the bot flies. They attack the higher animals. The larvæ of the kind commonly attacking horses live within the stomach; that on the cow, beneath the skin on the back.

If there is a proboscis, refer to 204.

204.

If the first hind cell is closed or nearly so, refer to 205.

If the first hind cell is not narrowed near the edge of the wing, it is one of the Anthomyidæ.

The Anthomyidæ have the general appearance of the common house flies. The larvæ live on plants, and some are parasitic on other insects.

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205.

If the arista of the antennæ is like a bristle, it is one of the Tachinidæ.

The young of the family Tachinidæ live almost entirely as parasites in other insects.

If the arista of the antennæ is like a feather, refer to 206.

206.

If only half of the arista is like a feather, and the other half like a bristle, it is one of the Sarcophagidæ.

The larvæ of the Sarcophagidæ feed both with other insects as parasites, and upon decaying vegetable substances.

If all the arista is like a feather, refer to 207.

207.

If there are long bristles on the back of the abdomen, as well as the finer hairs, it is one of the Dexidæ.

The Dexidæ include some of the commonest house flies. They feed as larvæ on decaying substances, and some are parasitic in other insects.

If there are no long bristles on the back of the abdomen, unless there be a few near the tip, it is one of the Muscidæ.

The larvæ of the Muscidæ feed on decaying substances. One species, the screw worm, often attacks men, laying eggs in the nose, which soon produce maggots, which devour the skin and flesh of the inside of the nose.

208.

If the wings are pointed at the tip, and have no cross veins, it is one of the Lonchopteridæ.

The Lonchopteridæ is a small family of flies, the habits of which are not known.

If the wings are rounded at the tip and there is a cross vein near the middle, refer to 209.

209.

If the fourth vein goes to the front edge of the wing, it is one of the Scenopidæ.

The Scenopidæ is a small family. The larvæ live on fungi.

If the fourth vein goes to the outer edge of the wing, refer to 210.

210.

If the third basal cell reaches nearly to the edge of the wing, it belongs to the Bombylidæ.

The Bombylidæ is a rather large family of active flies, found on flowers. The larvæ are parasitic on other insects.

If the third basal cell goes to nowhere near the edge of the wing, refer to 211.

211.

If the discal and second basal cells are united, it is one of the Dolichopodidæ.

The Dolichopodidæ is a rather large family of flies, the larvæ of which live under bark of rotten logs.

If the discal and second basal cells are separate, refer to 212.

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212.

If the head is narrower than the thorax, it is one of the Empidæ.

The Empidæ capture and feed on other insects. The larvæ have been found in the ground, but their habits are not known.

If the head is wider than the thorax, it is one of the Platypezidæ.

A very small family of flies, whose larvæ feed on fungi.

213.

If the proboscis is horny, it is one of the Asilidæ.

The Asilidæ are rather large flies, which capture and feed on other insects. The larvæ probably feed on the roots of plants.

If the proboscis is not horny, refer to 214.

214.

If the third joint of the antennæ is divided into several distinct rings, it is one of the Midaidæ.

The Midaidæ is a small family of large flies. The larvæ are parasitic on other insects.

If the third joint of the antennæ is not divided, refer to 215.

215.

If all the third vein goes to the front edge of the wing, it is one of the Apioceridæ.

A small family of very peculiar appearance. The larvæ are not known.

If the hind branch of the third vein goes to the outer edge of the wing, it is one of the Therevidæ.

The family Therevidæ is composed of a small number of flies, which as larvæ feed on fungi.

216.

If the third joint of the antenna is marked with rings, refer to 219.
If the third joint of the antenna is not marked with rings, to 217.

217.

If the thorax and abdomen are greatly swollen, it is one of the Acroceridæ.

The Acroceridæ are very peculiar flies. The larvæ are supposed to be parasitic.

If the thorax and abdomen are not greatly swollen, refer to 218.

218.

If there are spurs on any of the shanks, it is one of the Leptidæ.

The larvæ of the Leptidæ are parasitic on other insects.

If there are spurs on none of the shanks, it is one of the Nemestrinidæ.

The Nemestrinidæ are found about flowers, but their habits are not known.

219.

If the front shanks have spurs, refer to 220.
If there are no spurs on the front shanks, to 221.

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220.

If the palpi are swollen at the tip, it is one of the Xylophagidæ.

The larvæ of the Xylophagidæ feed on decaying vegetable substances, being often found under the bark of rotten stumps.

If the palpi are not swollen at the tip, it belongs to the Cœnomyidæ.

The Cœnomyidæ have the same habits as the Xylophagidæ.

221.

If there is a large white scale on the thorax beneath the wing, it is one of the Tabanidæ.

The Tabanidæ are the horse flies. The larvæ live in damp earth or even in the water, and feed on decaying vegetable substances.

If there is no large scale beneath the wings, it is one of the Stratomyidæ.

The larvæ of the Stratomyidæ live in the ground and in other damp situations, feeding on decaying vegetable substances.

222.

If the thorax has a V-shaped furrow in the back, it is one of the Tipulidæ.

The young of the family Tipulidæ live on the roots of plants, and occasionally do considerable injury. The flies are slender, but quite a number are over an inch in length.

If there is no V-shaped furrow on the back, refer to 223.

223.

If there is a vein bordering the whole wing, refer to 224.

If there is no vein along the hind edge of the wing, to 227.

224.

If there is only one basal cell, it is one of the Psycodidæ.

The larvæ of the Psycodidæ live in decaying vegetable substances.

If there is more than one basal cell, refer to 225.

225.

If the second and fourth veins are forked, refer to 226.

If the second and fourth veins are not forked, it is one of the Orphnephilidæ.

A small family of flies, whose habits are not known.

226.

If the veins are very hairy, it is one of the Culicidæ.

These are the mosquitoes. The larvæ are the wrigglers common in standing water.

If the veins are not hairy, it is one of the Dixidæ.

The habits of these insects are not well known.

227.

If there are three small eyes, besides the large ones, on the head, refer to 228.

If there are no small eyes on the head, to 231.

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228.

If there is a discal cell, it is one of the Ryphidæ.

The larvæ of the Ryphidæ live in decaying vegetable substances.

If there is no discal cell, refer to 229.

229.

If the wings have a large number of cracks, as though caused by folding, it is one of the Blepharoceridæ.

The habits of the Blepharoceridæ are not known.

If the wings have not these cracks, refer to 230.

230.

If the antennæ are much longer than the head, it is one of the Mycetophilidæ, unless there are no spurs on the shanks, when it is one of the Cecidomyidæ.

The Mycetophilidæ are delicate little flies. They feed as larvæ on a great variety of substances, mostly fungi and decaying vegetable matter.

If the antennæ are not much longer than the head, it is one of the Bibionidæ.

The Bibionidæ live as larvæ both on the roots of plants and on decaying substances, especially dung.

231.

If there are only four veins in the wings, it is one of the Cecidomyidæ.

The most destructive insect belonging to the family is the Hessian fly. The larvæ of most of the species are more or less injurious to plants, and many species cause swellings, in which they live.

If there are more than four veins, go to 232.

232.

If the fifth vein is forked, it is one of the Chironomidæ.

The larvæ of the Chironomidæ live in the water and furnish an important part of the food of fishes. The full-grown insects resemble mosquitoes.

If the fifth vein is not forked, it is one of the Simulidæ.

The flies of the family Simulidæ are known as buffalo gnats. They suck the blood of animals, and in some places become at times so numerous as to kill large animals. The larvæ live in the water.

SYNOPSIS OF THE FAMILIES OF HYMENOPTERA.

But few of the Hymenoptera are injurious, and a great many are beneficial. The females of the higher forms are armed with stings. The larvæ of many are known, but not enough to make a synopsis covering them.

233.

If the abdomen is fastened to the thorax across its whole width, refer to 266.

If the abdomen is greatly narrowed where it joins the thorax, to 234.

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234.

If the first joint of the hind foot is large, broad, and flat, refer to 235.
If the first joint of the hind foot is slender, to 236.

235.

If the tongue is short and flattened, it is one of the Andrenidæ.

This family includes the bees that do not live in colonies.

If the tongue is long and slender, it is one of the Apidæ.

The common hive bee, the bumble bees, and a few other social forms constitute this family. They feed their young on pollen and honey.

236.

If there is at least one closed submarginal cell, or when there are no wings if the body is ant-like, refer to 237.
If there are no closed submarginal cells in the wings, or when there are no wings at all if the body is thick and short, to 263.

237.

If there is but one small joint between the coxa and the thigh, refer to 238.
If there are two small joints between the coxa and the thigh, to 258.

238.

If there are large scales or humps on the back of the joints of the slender part of the abdomen, refer to 254.
If there be no such scales or humps on the slender part of the abdomen, to 239.

239.

If the wings are folded, refer to 240.
If the wings are not folded, or if there are none at all, to 242.

240.

If the antennæ are swollen at the end, it is one of the Masaridæ.

Nothing is known of the habits of this little family.

If the antennæ are not swollen at the end, refer to 241.

241.

If the middle shanks have one spur at the end, it is one of the Eumenidæ.

Some of these insects make their nests in holes in the ground or in plants, while others construct cells of mud, which are often attached to leaves or stems of plants. They feed on other insects.

If there are two spurs at the end of the middle shanks, it is one of the Vespidæ.

This family includes the wasps which live in communities. The nests are made of paper, either above or below the ground, and the young are fed with other insects. One species is injurious in this State, on account of its attack on ripe fruit.

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242.

If the prothorax touches the tegula, refer to 251.
If the prothorax does not touch the tegula, to 243.

243.

If the front wings have two closed submarginal cells, refer to 244.
If there are three closed submarginal cells, to 245.
If there is only one closed submarginal cell, it is one of the Crabronidæ.

Some of the insects of this family make their nests in burrows in wood, enlarging nail holes in posts, and the like, but some have the habit of burrowing into the pith of plants for the same purpose. They might, if abundant, do injury in this way. They provision their nests, as do most wasps, with other insects.

244.

If the thorax is narrowed in front into a long neck, it is one of the Ampulicidæ.

The habits of this rare little family are not known.

If the thorax is not so narrowed, it is one of the Pemphredonidæ.

The insects of this family burrow into the stems of plants, and only need to become numerous to do considerable injury.

245.

If the narrow part of the abdomen is long and slender, so that the rest of the abdomen is a long way from the thorax, refer to 249.
If the large part of the abdomen is very close to the thorax, to 246.

246.

If both recurrent veins are opposite the second submarginal cell, refer to 247.
If one recurrent vein is opposite the second, and one opposite the third submarginal cell, it is one of the Philanthidæ, unless the insect is quite hairy, when it is one of the Andrenidæ.

The Philanthidæ make nests in the ground, which they provision with other insects.

247.

If there are short veins between the marginal cell and the edge of the wing, it is one of the Larridæ.

The Larridæ is another family of burrowing wasps, with the same habits as the related ones.

If there are no short veins between the marginal cell and the edge of the wing, refer to 248.

248.

If the upper lip is short, it is one of the Nyssonidæ.

The habits of these insects are not very well known. Some burrow into plants, but they will probably never become abundant enough to prove injurious.

If the upper lip is long, it is one of the Bembecidæ.

The insects of this family make burrows in the earth like other digger wasps.

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249.

If one of the recurrent veins is opposite the first submarginal cell, it is one of the Mellinidæ.

The habits of the Mellinidæ are not known, but are undoubtedly like those of the related families.

If none of the recurrent veins are opposite the first submarginal cell, refer to 250.

250.

If the middle shanks have two spurs at the end, it is one of the Sphecidæ.

This family includes some well-known wasps, the mud daubers. Others burrow in the ground. They all provision their nests with spiders or other insects.

If there is only one spur at the end of the middle shank, it is one of the Mimesidæ.

A small family, with habits probably like the Sphecidæ.

251.

If the abdomen has a deep furrow beneath, between the first and second joints, refer to 252.

If the abdomen does not have this furrow, to 253.

252.

If the middle shanks have two spurs at the end, it is one of the Mutillidæ.

Many of these insects are very ant-like in appearance. They do not live in colonies, and provision their nests with other insects.

If there is only one spur at the end of the middle shanks, it is one of the Scoliidæ.

The habits of these insects are not well known. Some are supposed to be parasitic, while others dig holes in the ground for nests, like other wasps. None are injurious.

253.

If the hind legs are so short as not to reach the end of the abdomen, it is one of the Sapygidæ.

These insects are probably parasitic, but their habits are not well known.

If the hind legs are quite long and reach beyond the end of the abdomen, it is one of the Pompilidæ.

The Pompilidæ is a large family of wasps, mostly making burrows in the ground, and provisioning their nests with other insects.

254.

If the slender part of the abdomen is a single joint, refer to 255.

If the slender part of the abdomen is two jointed, it belongs to the Myrmicidæ.

The Myrmicidæ is one of the two large families of ants. They live in colonies, most of the inhabitants of which are wingless females. The winged forms appear about once a year.

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255.

If the large part of the abdomen is narrowed between the first and second joints, it is one of the Poneridæ.

The Poneridæ is a very small family of ants.

If the abdomen is not so narrowed, refer to 256.

256.

If the jaws are very close together where they join the head, it is one of the Odontomachidæ.

This is a very small family of ants.

If the jaws are not close together where they join the head, refer to 257.

257.

If the piece above the upper lip is very small, it is one of the Dorylidæ.

The Dorylidæ is a very small family of ants.

If the piece above the upper lip is rather large, it is one of the Formicidæ.

The Formicidæ is a large family of ants. Like the other ants, they live in colonies, in which are mostly wingless females, but about once a year the winged males and females appear.

258.

If the wings have no vein along the front edge, it is one of the Cynipidæ.

These insects live in swellings, called galls, which they produce on plants. They are generally not numerous enough to be injurious, and the "nut-galls" used in making ink are produced by a species of this family.

If there is a vein along the front edge of the wing, refer to 259.

259.

If the abdomen is joined to the back of the thorax, it is one of the Evaniidæ.

The Evaniidæ is a small family of useful insects living, till full grown, in the bodies of other insects.

If the abdomen is attached to the end of the thorax, refer to 260.

260.

If the front wings have a costal cell, refer to 261.

If the front wings have no costal cell, to 262.

261.

If the eyes are close to the jaws, it is one of the Trigonalidæ.

The Trigonalidæ is a small family of parasitic insects.

If the eyes are not close to the jaws, it is one of the Stephanidæ.

This is another small family of parasitic insects.

262.

If there are two recurrent veins, it is one of the Ichneumonidæ.

One of the largest and most important families of these useful insects. They are parasites, chiefly on the larvæ of Lepidoptera.

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If there is but one recurrent vein, it belongs to the family Brachonidæ.

These are also important and useful parasites.

263.

If the antennæ are bent like an elbow, refer to 264.

If the antennæ are not bent, it is one of the Pelicinidæ, unless they are less than an inch in length, when, if the abdomen is joined to the back of the thorax, it is one of the Evaniidæ, or if to the end, it is one of the Brachonidæ.

The Pelicinidæ include a single American species, the habits of which are not known.

264.

If the abdomen appears to have only three to five joints, and is hollowed out beneath, it is one of the Chrysididæ.

These insects live in the nests of other Hymenoptera in their early stages. The shape of the abdomen allows it to coil up into a ball.

If the abdomen has many joints, and is not hollowed out beneath, refer to 265.

265.

If the prothorax touches the tegulæ, it is one of the Chalcididæ.

A large family, living until full grown as parasites within the bodies of other insects. They are mostly of very small size, and are among our most useful insects. One group, however, is composed of vegetable feeders, and are the "joint-worms" of wheat.

If the prothorax does not touch the tegulæ, it is one of the Proctotrupidæ.

The Proctotrupidæ resemble very much the Chalcididæ, both in habits and in appearance.

266.

If the front shanks have two spurs at the end, it is one of the Tenthredinidæ.

The Tenthredinidæ are the sawflies. Their larvæ are sometimes called slugs. They feed on the leaves of trees, and are very injurious. The eggs are generally laid within the leaf. The larvæ have eighteen to twenty-two legs, and the pupa is generally in the ground.

If there is one spur at the end of the front shanks, it is one of the Uroceridæ.

These insects are commonly known as horn-tails. The eggs are laid beneath the bark of trees, and the larvæ are borers. They can do considerable injury to timber.

EXPLANATION OF TERMS.

All the scientific terms used in the synopsis are shown in the figures, but the following explanations are added to prevent any possible misunderstanding of the figures:

ABDOMEN. All the hinder part of the body after the thorax.

ANTENNA (plural, *Antennæ*). The only jointed organ on the head of insects besides the mouth parts. It is often long, slender, and many-jointed.

ARISTA. A large bristle, which forms a very conspicuous parts of the antennæ of most flies. The term is only used in the order Diptera.

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AUXILIARY VEIN. A small vein, almost parallel with the first vein. Only present in the order Diptera.

CELL. Any part of the wing of an insect bounded by but not including veins. If veins entirely surround a cell, it is said to be closed, otherwise it is open.

CLAWS. Hook-like organs at the end of the foot.

COXA (plural, *Coxæ*). The first joint of the leg. It is generally sunken into the body, but sometimes it is very long and but little sunken into the body.

COXAL CAVITIES. The holes into which the coxæ fit.

CROSS VEIN. Short veins connecting the principal veins.

DISCAL CELL. A particular cell near the middle of the wing.

ELYTRON (plural, *Elytra*). The front wing of Coleoptera. They are thick and hard organs.

EPIPLEURA (plural, *Epipleuræ*). The part of the elytra that can be seen from beneath.

HIND INTERCALARY VEIN. A vein found in the hinder part of the wing in a few flies.

MESOSTERNUM. The piece between or in front of the middle pair of legs.

METASTERNUM. The piece between and in front of the hind pair of legs.

OCELLUS (plural, *Ocelli*). Small eyes, two or three in number, found on the heads of most insects in addition to the larger eyes.

PROSTERNUM. The breast of the prothorax. The piece between or in front of the front legs.

PROTHORAX. The first joint of the body back of the head.

RECURRENT VEIN. The cross veins below the series of submarginal cells. (See the figure.) This term is only used in the order Hymenoptera.

SPRING. A peculiar organ in certain families of the Thrysanura, by means of which they can leap.

SPURIOUS VEIN. A vein crossing the front cross vein. Generally quite feeble. This term is only used in one family of the order Diptera.

SPURS. Sharp spines found at the end of the shanks of most insects.

SUBMARGINAL CELL. A row of cells near the front edge in Hymenoptera. (Compare the figures.)

TEGULA (plural, *Tegulæ*). The part of the thorax in Hymenoptera at the attachment of the wings.

THORAX. The part of the body between the head and the abdomen. All the legs and wings come from this part. It consists of three joints. Sometimes these are all fastened together, and the last two are always fastened together in the full-grown insect.

VEIN. The stiffening ribs of the wings.

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CALIFORNIA.

Pacific Tree and Vine, San José.
Rural Californian, Los Angeles.
Chino Valley Champion, Chino.
Weekly Gazette, San Francisco.
The Progress, Palermo.
California Cultivator and Poultry Keeper, Los Angeles.
California Prohibitionist, San José.
Corning Observer, Corning.
Press and Horticulturist, Riverside.
Citrograph, Redlands.
Central Californian, Fresno.
San José Daily Herald.
Weekly Times-Index, San Bernardino.
Fresno Weekly Republican.
Four Corners, Wheatland.
Pacific Rural Press, San Francisco.
Redondo Beach Compass.
Porterville Enterprise,
L'Union Nouvelle, Los Angeles.
Le Progress, Los Angeles.

FROM OUTSIDE THE STATE.

Industrial American, Lexington, Kentucky.
Holstein-Friesian Register, Boston, Massachusetts.
Ladies' Home Companion, Philadelphia.
Florida Agriculturist, De Land, Florida.
Farm and Fireside, Philadelphia.
Farmers' Review, Chicago.
Home and Farm, Louisville, Kentucky.
The Farmer's Home, Dayton, Ohio.
Orange-Judd Farmer, Philadelphia.
Farm and Home, Chicago and Springfield, Massachusetts.
Northwest Horticulturist, Tacoma and Seattle, Washington.
The Rural Northwest, Portland, Oregon.
The Pharmaceutical Era, Detroit.
The Farm Journal, Philadelphia.
The Louisiana Planter, New Orleans.
Colorado Farmer, Denver, Colorado.
Vick's Magazine, Rochester, New York.
The Sugar Beet, Philadelphia.
Baltimore Weekly Sun.
Mirror Farmer, Manchester, New Hampshire.
American Grange Bulletin and Scientific Farmer, Cincinnati.
The Grange Visitor, Lansing, Michigan.
Garden and Field, Adelaide.
Southern Cultivator and Dixie Farmer, Atlanta, Georgia.
Hospodar (Hungarian), Omaha, Nebraska.
Die Nation, Berlin.
Tiroler Landwirthschaftlicher Blätter, S. Michele.
Kawkab America (Turkish), New York.

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AGRICULTURAL EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA,

IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

		Dr.	Cr.
1892.	To receipts from the Treasurer of the United States, as per appropriation for year ending June 30, 1892, under Act of Congress, approved March 2, 1887		$15,000 00
June 30—	By buildings	$244 33	
	By furniture	87 50	
	By fencing and drainage	3 17	
	By freight and expressage	106 77	
	By incidentals	69 75	
	By labor	5,485 49	
	By postage and expressage	18 15	
	By salaries	5,679 96	
	By supplies	2,072 34	
	By tools, implements, and machinery	200 35	
	By traveling	254 54	
	By water supply	777 65	
	Totals	$15,000 00	$15,000 00

We, the undersigned, duly appointed members of the Finance Committee of the Regents of the University of California, do hereby certify that we have examined the books and accounts of the Experiment Stations of the University of California, for the fiscal year ending June 30, 1892; that we have found the same well and correctly kept and classified as above, and that the receipts for the time named are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
ALBERT MILLER,
I. W. HELLMAN,
Finance Committee of the Regents of the University of California.

I hereby certify that the foregoing statement, to which this is attached, is a true copy from the books of account of the institution named.

J. J. HERR,
Auditor.

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UNIVERSITY OF CALIFORNIA—COLLEGE OF AGRICULTURE.

AGRICULTURAL EXPERIMENT STATION.

REPORT OF WORK

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OF THE

AGRICULTURAL EXPERIMENT STATIONS

OF THE

UNIVERSITY OF CALIFORNIA,

FOR THE YEAR 1892-93 AND PART OF 1894.

BEING A PART OF THE REPORT OF THE REGENTS OF THE UNIVERSITY.

SACRAMENTO:

STATE OFFICE, : : : : : A. J. JOHNSTON, SUPT. STATE PRINTING.

1894.

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REPORT OF THE PROFESSOR OF AGRICULTURE AND DIRECTOR OF THE EXPERIMENT STATIONS

TO THE

PRESIDENT OF THE UNIVERSITY.

E. W. HILGARD, DIRECTOR.
E. J. WICKSON, ACTING DIRECTOR, 1892-3.

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SPECIAL NOTICE TO PERSONS SENDING SAMPLES FOR EXAMINATION TO THE EXPERIMENT STATION.

1. The work of the Station being designed for the benefit of the agricultural public, we do not undertake to investigate matters of purely private interest, unless conclusions subserving the public interest can be drawn therefrom. The Station does not undertake to solve riddles for the merely curious. It should, however, be understood that the examination of soils, waters, insects, plants, and other natural or new materials of interest to the agriculturist forms part of the general plan of investigation of the resources of the State. So far, therefore, as any such examination fills a gap in our knowledge of the State, it will fall within our province, even though for the moment benefiting only an individual. Special directions for the proper taking of soils and waters will be sent on application.

2. In order to insure attention and examination, every sample sent must be accompanied by a full statement of the origin, mode of occurrence, or special nature of the object sent, with a mention of the particular points upon which information is desired, and the object in view in asking the question. Without such information the Station would in many cases have to go to an amount of trouble quite disproportionate to the value or importance of the object to be attained, nor would the public interest be subserved.

3. Every package sent should always be distinctly marked with the sender's name and post office, even when a letter is inclosed in it. Whether sent by mail or express, all packages must be *prepaid by the sender*, unless sent by special request of the Station.

4. Reports of such examinations will be sent by letter when completed, and the results will be published in the ensuing annual reports of the Station. The annual reports and bulletins will be mailed free to any resident of the State requesting the same.

Remember that your package is but one of many that may arrive on the same day, and that our staff cannot afford to spend their time in comparing and identifying the handwriting on letters and packages; also, that for the same reason immediate action upon the sample cannot be expected, but that you must take your turn among the rest. If for particular reasons an immediate answer is desired, state the fact and the reasons therefor, and so far as possible examination will be expedited.

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EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA, 1893-94.

CENTRAL STATION (Berkeley, Alameda County).

E. W. HILGARD, Ph.D., LL.D. (Professor of Agriculture), Director and Chemist.
E. J. WICKSON, M.A. (Associate Professor of Agriculture, Horticulture, and Entomology), Superintendent of Agricultural Grounds.
E. L. GREENE, Ph.B. (Associate Professor of Botany), Botanist.
R. H. LOUGHRIDGE, Ph.D. (Assistant Professor), Agricultural Geologist and Agricultural Chemist.
C. W. WOODWORTH, M.S. (Assistant Professor), Entomologist.
M. E. JAFFA, Ph.B. (Instructor), First Assistant Chemist in Agricultural Laboratory.
ARTHUR P. HAYNE, Ph.B. (Instructor), Assistant in charge of Viticulture and Olive Culture.
GEO. E. COLBY, Ph.B. (Instructor), Second Assistant Chemist in Viticultural Laboratory.
C. H. SHINN, A.B., Inspector of Stations.
EMIL KELLNER, Foreman of Station Grounds.
F. T. BIOLETTI, B.S., Foreman of Viticultural Cellar.
A. V. STUBENRAUCH, Clerk to the Director.

SIERRA FOOTHILL STATION (near Jackson, Amador County).

R. C. RUST, Patron; Jackson.
GEORGE HANSEN, Foreman; Jackson.

SOUTHERN COAST RANGE STATION (near Paso de Robles, San Luis Obispo County).

GEORGE R. ADAMS, Patron; Paso Robles (resigned June, 1894).
R. W. PUTNAM, Patron; Paso Robles (appointed June, 1894).
W. H. TYSON, Foreman; Paso Robles.

SAN JOAQUIN VALLEY STATION (near Tulare City, Tulare County).

A. J. PILLSBURY, Patron; Tulare City.
JULIUS FORRER, Foreman; Tulare City.

SOUTHERN CALIFORNIA STATION (near Pomona, Los Angeles County).

RICHARD GIRD, Patron; Chino.
K. MCLENNAN, Foreman; Pomona (resigned October, 1893).
J. W. MILLS, Foreman; Pomona (appointed October, 1893).

CHICO FORESTRY STATION (near Chico, Butte County).

C. C. ROYCE, Patron; Chico (resigned June, 1894).
R. F. PENNELL, Patron; Chico (appointed June, 1894).
A. B. BOLAND, Foreman; Chico.

SANTA MONICA FORESTRY STATION (near Santa Monica, Los Angeles County)

H. J. KRUCKEBERG, Patron; Santa Monica.
WM. J. STRACHAN, Foreman; Santa Monica.

VITICULTURAL STATION (under private auspices).

EAST SIDE SANTA CLARA VALLEY STATION; Mission San José, Alameda County. John Gallegos, Patron; Mission San José.

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COURSES IN AGRICULTURE AT THE UNIVERSITY OF CALIFORNIA.*

AGRICULTURAL CHEMISTRY—

1. *General Course.* (*a*) Chemistry and Physics of Plants, three times a week during the first term. (*b*) Soils and Theory of Culture, three times a week during the second term. Professor Hilgard and Assistant Professor Loughridge.
2. *Vinification.* Lectures twice a week during the first term, with practical cellar-work. Mr. Hayne and Mr. Bioletti.
3. *Agricultural and Viticultural Laboratory.* Twelve to fifteen hours a week during both terms. Mr. Jaffa and Mr. Colby.

AGRICULTURE AND HORTICULTURE—

4. *General Course.* Three times a week during both terms. Associate Professor Wickson.
5. *Viticulture and Olive Culture.* Twice a week during the second term. Mr. Hayne.
6. *Special Courses* given as called for.

ENTOMOLOGY—

7. *Elementary and Economic Entomology.* (*a*) Lectures and laboratory work, twice a week during the first term. (*b*) Supplementary laboratory work, once a week during the first term. Assistant Professor Woodworth.
8. *Apiculture.* (*a*) Lectures, laboratory and apiary work, twice a week during the second term. (*b*) Supplementary laboratory and apiary work, once a week during the second term. Assistant Professor Woodworth.
9. *Parasitic Plant Diseases.* Lectures twice a week during the first term. Assistant Professor Woodworth.
10. *Systematic Entomology.* Lectures three times a week during the second term. Assistant Professor Woodworth.
11. *Structural Entomology.* Lectures three times a week during second term. Courses 10 and 11 are given in alternate years. Assistant Professor Woodworth.
12. *Entomological Laboratory.* Two or three times a week throughout the year. This course can only be taken with or after Courses 9, 10, or 11. Assistant Professor Woodworth.

AGRICULTURAL SEMINARY—

13. Elementary course for study of current agricultural literature, once a week during both terms. Associate Professor Wickson and other instructors.

*In addition to the general requirements in mathematics, literature, languages, and general sciences; for detailed description of which see the General University Register.

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LETTER OF TRANSMITTAL,

AND REPORT ON INSTRUCTION AND EXPERIMENT STATION WORK.

President MARTIN KELLOGG:

DEAR SIR: I transmit herewith the manuscript of the report on the work of the Experiment Station since the issuance of the previous one (1891–92), for your approval and transmission to the State Printer. In actual time, it covers the work of the financial year 1892–93 (under the eminently satisfactory direction of Professor Wickson) and up to January, 1894. In view of the unforeseen delays in its completion, some of the more important investigations of the first half of the year 1894, made in the laboratory of the Central Station, have also been included, so as not to unduly delay their publication, since financial considerations forbade their issuance in bulletin form.

Instruction.—In view of the intimate connection existing between the Experiment Station work and that of instruction, it becomes necessary to discuss both conjointly, since with one exception the entire Station staff takes part in both. The double duties thus imposed must account for the delay in the transmission of this report, which should have been ready six months ago; in this instance the preparation of the report on the exhibit of the soils of the United States at the Chicago World's Fair, made to the World's Fair Committee, and the preparations for the Midwinter Fair, have imposed additional delay; and the entire summer vacation has been occupied by the staff in its completion.

I must, in justice to this department, call attention to these facts, since the relatively small number of students attending some of the agricultural lecture courses is frequently made the basis of suggestions toward the reduction, instead of increase, of our working force. It should be abundantly apparent to any one that a lecture course involves the same amount of time and forethought with small as with large classes; so that if agricultural instruction is to be given at all in accordance with the provisions of the two Morrill Acts, a proper staff, in numbers as well as in specific qualifications, must be provided for the purpose. Among the deficiencies in our provision for instruction, to which I have called attention annually for many years past, is the absence of a chair of Veterinary Science; a serious gap, which exists in but few of the agricultural colleges of the United States. While fully aware of the financial difficulties which at present confront the University, I cannot omit to enter once more a *caveat* on this subject.

While in the case of the lecture courses the number of students forming each class does not alter the labor involved, it is quite otherwise with laboratory students. Of these, we have during the last three years had as many as could be accommodated with work-desks; and as each one requires individual attention on the part of Instructors Jaffa and Colby, the station work by these assistants has thereby been materially interfered with, and but for the temporary appointment of extra help (Mr. Marvin Curtis) during a portion of the last session, would now be hopelessly in arrears. As the interest in this work on the part of the

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population, therefore its volume, increases, it will become indispensable to provide either for additional aid in instruction, or in the experimental work. Fortunately, the thesis work of some advanced students, who chose questions requiring investigation, has in a measure served to complement our work; and hence their theses are reproduced with this report.

Lectures and Correspondence.—Another line of duty which adds materially to the labors of some of the staff, is the preparation for, and attendance at, Farmers' Institutes, Conventions, and other meetings of similar character, coupled with the fact that in most cases the papers read or discourses made have to be prepared for publication. A report of this work, by Professor Wickson, is transmitted herewith. The instruction thus given to public audiences, and to the readers of the proceedings, should fairly be placed to the credit of instruction in the College of Agriculture; no less than the 2,500 to 3,000 letters written annually by the different members of the staff. This, as well as the writing and making-up of the reports and bulletins, are duties which considerably more than offset the Extension Courses of any other department of the University.

It should be understood that out of the numerous examinations made of specimens sent to the Station, and reports made thereon, a large proportion are omitted from even mention in the present report; not being of sufficient general interest, save as links in the chains of facts which should ultimately serve for a complete description and map of the agricultural and industrial features of the State.

Equipment for Instruction and Work.—I cannot omit in this connection to call attention again to our still very deficient equipment as regards both instruction and experimental work in the College of Agriculture. In this we lack many conveniences required for effective demonstration and quick execution of laboratory work, which are elsewhere considered indispensable in order to keep abreast of the progress made in this respect. The lack of these appliances involves a vast amount of time lost in mounting, dismounting, and reconstructing apparatus, that should be duplicated several times over in order to work to the best advantage; not to speak of the disadvantage to instruction which results from imperfect means of demonstration. I respectfully call attention to the statements made in connection with this subject in the special report on European Agricultural Colleges in a subsequent part of this report.

I may add that the new and important connections established by us with foreign institutions, as a result of my visit to Europe, have added materially to the burden of correspondence, and that hereafter an absolutely essential qualification of the Director's Clerk must be an adequate knowledge of at least one of the modern languages (either German or French), together with a sufficient practice in typewriting, and if possible stenography, to relieve the Director of personal burdens which it will become impossible to bear unassisted.

Early Course for Students—Lower Schools.—In reference to possible increase of students in the agricultural course, it is hoped that the modifications made in remodeling the course during the last session will be conducive to that end. As it has seemed desirable that the agricultural students should come in contact with the department instructors earlier in the course than has been the case heretofore, so as to begin their distinctive studies at once upon entering college, arrangements have been made for weekly exercises of a seminary character, taking as a

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basis the current literature of agricultural journals and station bulletins, thus familiarizing them with the problems of modern agricultural science, and interesting them in the questions of the day. These exercises are open to all students interested, and while under the general charge of Associate Professor Wickson, will be participated in successively, according to the nature of the subjects to be presented, by all the instructors in the agricultural courses proper.

Two-years' Course.—In the absence of any instruction in agricultural topics in the schools below university grade, those who would otherwise attend such instruction in the lower schools usually come to the University for two years, or less; and under the present regulations they can only enter in the category of "special students." These regulations are frequently, however, but illy applicable to the cases of such students, in more than one respect. It would seem advisable, in view of the fact that two-year courses are most in demand, that they should be definitely recognized and formulated, and that a definite certificate on the part of the College of Agriculture and of the University should take the place of the mere certificates of record heretofore given in such cases.

It may be objected to this plan that such recognition might diminish still further the number of students taking the full four years course, and I confess that this consideration has prevented me from making the above recommendation at an earlier time. But in my study of the conditions of agricultural education in Europe, I have become convinced that the paucity of students in the agricultural course of university grade is largely due to the fact that definite careers for students pursuing such a course are, in the nature of the case, very much less abundant in this country than in Europe, where government positions and the superintendence of large properties offer them a larger attractive field. While, therefore, I hope and believe that with the constantly increasing necessity for a more rational system of agriculture, due to the progressive exhaustion of our virgin soils, the demand for thoroughly and professionally trained agriculturists will steadily increase, and while I also believe that the University diploma should be rigorously reserved to those who in addition to such professional training are otherwise culturally equipped to become leaders in such profession, I also think that so far as in us lies, the present demand should be met on our part by such arrangements as will make the educational advantages of the College of Agriculture freely available to all those who desire to use them, so far as their previous preparation will permit.

Training for College and Station Work.—Among the important functions required of our agricultural colleges, and the need of which is not yet sufficiently appreciated even by themselves, is the education of men specially trained to fit them for positions in such colleges and stations. It is notorious that, thus far, but too many of the men occupying these positions are merely specialists in the particular branch represented by them, and are unable themselves to discuss the bearings of the results of their own work upon the general interests of agriculture. This narrowness of educational knowledge, inseparable from the sudden establishment of so many agricultural colleges and experiment stations, must be held responsible for a great deal of the crude and undigested matter now often found in station reports. Nor can men fitted for these positions be properly educated in the popular schools of agriculture so often urged as likely to be more useful than those of university grade. It

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cannot be too often nor too earnestly repeated that the first condition of reform or progress in any line is the availability of properly qualified leaders. Late events have emphasized this as regards industrial and social conditions in other branches; it is no less emphatically true in reference to the agricultural industry.

EXPERIMENTAL WORK.

Viticulture and Olive Culture.—The resignation by Mr. Paparelli of the assistantship in charge of Viticulture and Olive Culture, left the department with the unelaborated record of considerable work done by him during his incumbency, which, in the absence of his personal coöperation, it will be difficult to utilize fully. Such losses are among the unavoidable infelicities attending a frequent change of workers.

His successor, Mr. A. P. Hayne, has however taken hold energetically of the problems of both branches of his subject. His paper on "Olives and Olive Oils," being a somewhat extended revision of a bulletin previously issued, is hereinafter given; and active preparations have been made for the continuation of similar studies during the present season by the issuance of circulars to olive growers, from whom it is hoped an extensive and varied supply of material for investigation will be obtained. We may thus hope to forestall the repetition of the numerous expensive mistakes heretofore made in connection with the olive industry.

In the line of *Viticulture*, Mr. Hayne, assisted by Mr. Bioletti, has nearly completed the report on the work done on white-wine grapes, which will complete the one already issued on red-wine grapes in 1892. This publication will, in a measure, round off that portion of the work which was specially designed to establish some definite starting points for comparison of the composition and quality of grapes, musts, and wines from the different climatic regions of the State. The same kind of work, it is true, must be continued on a somewhat reduced scale with the material now supplied by the outlying culture sub-stations. It is now intended, however, to resume and continue on a more extended scale the experiments on wine fermentation and conservation, specially with reference to the possible improvement of the product by selected ferments, which has yielded such important results in Europe. Now that there seems to be hope of a proper discrimination of the quality of wines in commercial circles, the preparation of the best possible product from a given material assumes financial importance.

The report on white-wine grapes will probably be ready for the press soon after the present one, and will as heretofore be issued separately.

Chemical Work on Wines and Fruits.—In addition to the usual series of analyses of musts and wines, belonging to the regular viticultural work, an extended series of analyses of fruits, among which olives take a prominent place, has been made by Assistant Colby during the period covered by this report; as shown in the record and discussion given below. The work on olives especially has attracted wide attention on account of its important practical bearing on the selection of varieties to be planted in different regions and for different purposes.

Agricultural Laboratory Work.—The analyses of feeding stuffs of various kinds, made at the suggestion or request of dairymen and stock-breeders, is becoming more prominent in the Station work, and has occupied a not inconsiderable portion of the time and attention of Assist-

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ant Jaffa; besides the usual complement in the way of examinations of soils, waters, fertilizers, rocks, clays, and other materials too numerous to mention, constantly being sent in from all parts of the State. It may become necessary, in order to relieve the pressure, to circumscribe more closely the character of the examinations which the Station will undertake to make. It has been said that the wide scope now given interferes to a certain extent with the legitimate occupation of commercial chemists. While it is true that any such interference by the Station is to be avoided, as is done in the case of nurserymen in our distribution of seeds and plants, it is also true that the reason why so many demands are made upon the Station for work of this kind is not so much the avoidance of a fee (which is very commonly freely offered) as the desire to obtain, besides the columns of figures usually furnished by such chemists, intelligent and disinterested interpretations of the results, together with the authority of the Station for the same. It is this very kind of demand which has in Germany (as hereinafter shown) increased enormously not only the work of the experiment stations (for which a moderate fee is charged), but also the aggregate amount of chemical work asked for in connection with agricultural interests.

Entomology and Plant Diseases.—Assistant Professor Woodworth's courses in general and economic entomology and plant diseases have been well attended during the past two sessions, between twenty and thirty students taking part in them, both in the laboratory and lecture-room. A special course in apiculture (bee-keeping) has been given for the first time during the session 1893–94, and will be regularly continued hereafter. In addition, Professor Woodworth has made numerous examinations of specimens of insects, diseased plants, etc., sent for inspection and identification and for suggestion of remedies. This has involved quite an extended correspondence, but the results are not generally of such a nature as to be utilized in this report. He has also attended a number of Farmers' Institutes.

Miscellaneous Chemical and Editorial Work.—A large number of minor examinations, made in answer to requests, accompanied by specimens, are constantly being made by Assistant Professor Loughridge, as well as by myself personally, in cases where such examinations involve, with only a limited amount of laboratory work, the exercise of a great deal of judgment. Such examinations, likewise, must largely remain without notice outside of the record books; although involving the expenditure of considerable time, as well as voluminous correspondence.

In addition, editorial work connected with the issuance of reports and bulletins devolves mainly upon Professor Loughridge, together with the preparation of the photographs which have now become an important part of the record of the Station. The illustrations in the present report are copies of such photographs. Professor Loughridge has, moreover, been steadily engaged in the pursuit of chemico-physical soil studies of a general character whenever time permitted, besides acting in my place in the instruction of the classes in agricultural chemistry whenever absence or other causes have prevented my personal performance of that duty.

The Work of the Culture Stations.—In view of the predominance of fruit-growing in California, the chief interest in the culture experiments at the several sub-stations has centered in the outcome of the orchards and vineyards planted at the time of their establishment. As a neces-

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sary consequence, results of such cultures are delayed for the number of years required to bring the trees and vines into bearing; and popular impatience has not always kept this fact in view. The time has now come when, after the lapse of from five to seven years, definite and valuable results may be looked for; and the extended reports on the several sub-stations hereinafter made by Inspector Shinn are an earnest of such results. That these, in a very large proportion of cases, will show a record of failures quite as heavy as of successes, is to be expected from the very nature of the experiments, which are intended to show what cannot, as well as what can, be done with certain species and varieties of fruits in the several climatic regions. The failures are just as important to the farmer as the successes, since they will prevent him from investing his money and efforts in profitless directions.

The management of these sub-stations from a distance, and with only occasional visits from the Inspector and Director, under foremen necessarily possessing little or no previous experience in experimentation, is far from an easy problem. It will be greatly facilitated when, in the progress of agricultural education in this country, there shall have been turned out from our own institutions a larger number of men specially qualified for the combination of practical scientific and administrative functions required in these positions. It may be confidently expected that as the utility, not to say necessity, of a large number of experimental sub-stations on our vast domain of indefinitely varied character becomes better understood, the number of such stations, and consequently the demand for well-qualified foremen, will become quite extensive and offer ample opportunities for employment to students educated in the agricultural colleges. Such positions will then, of course, require higher compensation than is now given our foremen, who at present receive merely gardeners' wages. Considering this limited inducement, I may say that at this time our foremanships are quite satisfactorily filled (one of them, the South California Station, by a former student who had a two-years' training at the College of Agriculture), and under the efficient supervision of Inspector Shinn, excellent work is being done.

In the case of three of the stations, located near to centers of population accessible by railroad, the work is well appreciated by the farmers of the regions concerned. Unfortunately, the station representing the foothill region, though excellently well located as regards soil and climate, still remains remote from railroad connection, contrary to the reasonable expectations entertained at the time of its establishment. This isolation is not conducive to its being appreciated by the fruit-growers of the foothills, who are chiefly interested in its operation; and are located mainly in Placer County, through which passes the Central Pacific Railroad, one of the great thoroughfares of the continent; at the same time the running expenses of this station are greatly increased from the same cause. It is, perhaps, to be regretted that at the time when its establishment was first contemplated no response to our invitation for offers of land and buildings was received from that prosperous region which initiated successful shipment of California fruits to the East, and has ever remained distinguished for the high quality of its products.

It is, of course, obvious that the four general culture stations thus far established outside of the Central Station at Berkeley, are not nearly sufficient to cover, in their cultural results, the immense agricultural area of

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California. But it is doubtful that even with the utmost restriction and economy in the operation of these stations after they are fully equipped, even one additional culture station could be maintained out of the fund at present devoted to the purpose, viz.: the $15,000 appropriated for experimental purposes under the Hatch Act. If additional stations are desired for *e.g.* the Sacramento Valley, the northern interior counties, the northern and southern coasts, and many other climatic and soil conditions not now represented, additional means will have to be provided from some source.

It is proper to state in this connection, that in consequence of the reduction of the University appropriation for the expenses of instruction and experimentation at the Central Station (from $8,000 to $6,000 per annum), it became necessary to suspend the issuance of bulletins during the past financial year. It has therefore been thought imperative to so restrict the expenditures of the culture stations as to enable us to defray from the Hatch Fund the expenses of issuing bulletins as heretofore. It is manifest that these publications are absolutely essential to the appreciation and practical utility of the Station work; and that (since there has been no increase of the appropriation for the coming financial year) it will be better to restrict the work than to omit the publications. While our bulletins may properly claim the right of publication through the State Printing Office, as is done with our reports (and should be done in the case of the longer and less pressing bulletins), yet the long delay usually inseparable from the use of this channel, renders it necessary to supplement it, at least, by the issuance of matter of immediate interest at the expense of the Station fund, as is done elsewhere.

The two Forestry Stations, which, by an Act of the last Legislature, were transferred to our care, unfortunately with a very inadequate appropriation for running expenses or improvements, have been actively taken in hand so as to render them productive of useful results within the shortest possible time that the nature of the case permits. The gratuitous distribution of trees, formerly made from these stations, and which formed a source of complaint against them on the part of nurserymen as interfering with their legitimate trade, has been discontinued; the small amount of stock remaining on hand having been distributed to public schools applying therefor. As shown in the detailed report of the Inspector, much has been accomplished during the past financial year in placing these stations on a practical working basis; but it will be necessary for the next Legislature to make a more adequate provision for their maintenance, if they are to be continued. No respectable or practically useful showing can be made with the $2,000 per annum heretofore granted for the purpose in lieu of the $10,000 expended annually by the Forestry Board.

The Distribution of Seeds and Plants, as hereinafter reported by Professor Wickson, continues to form a highly acceptable and useful portion of our culture work. Our former publications containing the reports returned from persons throughout the State who have been recipients of such distribution, are in such constant demand that before long they may in substance have to be reprinted. It is obvious that such reports, when made by careful persons (and this is usually obvious upon their face), successfully replace, for the time being and for the plants concerned, the operations of a local culture station.

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As from the nature of its location in an exceptional climatic belt, the cultures of the Berkeley Central Station are not representative of any extended climatic region, one of the chief functions performed by it is the growing of seed and stock for these distributions, as well as for the outlying culture stations, and for effecting exchanges with foreign institutions, societies, and Boards of Agriculture. These exchanges are rapidly assuming a wide scope and importance, and now extend all around the globe, so as to enable us to procure seeds and plants giving promise of successful culture in California, or which are otherwise of interest, from the most remote locations, with little expense beyond postage. Reference to the list of donations and of publications received will illustrate these facts.

The new *plant-house* now happily in progress of construction will, when completed, serve to utilize, both for instruction and experiment, a large proportion of the interesting plants received; of which several generations have heretofore perished, in consequence of lack either of space or of proper protection when grown. The wide climatic range embraced by the State of California, from the Oregon line to Mexico, compels us to provide for a correspondingly wide range of vegetable growths adapted to these numerous climates. We cannot properly propagate in the open air at Berkeley many of the culture plants adapted for trial in Southern California. Moreover, instruction in general as well as agricultural botany imperatively requires that a wide range of plants, illustrative of the vegetation of the whole globe, as far as possible, should be accessible to both students and instructors. Such illustrations are deemed essential in all educational institutions elsewhere; and however tolerant our climate may be, it does not exempt us from the necessity of providing artificial shelter for such foreign growths. The frequency with which the easy communication with foreign countries from San Francisco tempts our population to seek their fortunes in countries representing all climates from Alaska to the equator, render a cosmopolitan provision in these respects doubly important in our case.

I make this statement in view of the objection made in certain quarters, to the expenditure for the building of a plant-house, on the score of its being supposed to be unnecessary.

I am constrained to call attention to the fact that the improvements required to render the surroundings of the new plant-house sightly, not to say attractive, as they should be, cannot be defrayed out of the diminished appropriation of $6,000 for current expenses; nor can it be expected that the maintenance of the new plant-house will not cost more than that of the small and now decrepit structures that have heretofore been made to serve its purposes on the propagating-grounds. The new structure will enable us to take up lines of work for which thus far there have been no adequate facilities, however much needed; and we have reason to hope that while adding materially to the working facilities, it will also increase in a measure the attractiveness of the agricultural course.

Respectfully submitted.

E. W. HILGARD.

JULY 1, 1894.

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WORK IN ENTOMOLOGY AND PLANT DISEASES.

To Professor E. W. HILGARD:

The work of instruction has in this department been greatly increased by the addition of advanced courses. The amount of additional work thus incurred can be seen from the fact that when I took up the work, two hours of class exercises with no laboratory was all that was offered in this subject, while now twenty credit hours, or actually forty hours, of work, including the laboratory, is now taken. The number of students at first was larger than now, because of the fact that entomology was required to be taught in the public schools. Now that that artificial stimulus has been removed the present may be considered to represent more nearly the normal attendance.

The other work undertaken by the department consists in a systematic study of the local insect fauna, more particularly investigation of the species and groups of direct economic bearing; a study of the remedies and means of prevention of insect and fungous injury, and the answering of letters of inquiry from all sources concerning insects and related subjects.

In the faunal studies a large amount of material has been accumulated, but only a small part of it has as yet been put in shape for publication. This material will be strictly scientific and hardly suitable for incorporation in the report of the Experiment Station, and will have to be published in scientific journals. It would be of advantage to the University if such material could be issued by the Station in a series of technical bulletins, as is done in the Department of Geology and Mineralogy. In other institutions this is also done.

The economic studies, as far as completed, are presented herewith. It has been the policy to report only completed work, or at least only such work as has brought out important results, so that what is presented at any time does not represent the work of that year, but rather the accumulated observations on some very few topics.

The correspondence has increased steadily, and become indeed, at times, quite burdensome, especially as it is, to so large an extent, a repetition of the same set of questions. The publication of special Bulletin A, giving the remedies most commonly in use, has proven a great help, and indicates that further publications of this type will be most useful.

Very respectfully,

C. W. WOODWORTH,
Assistant Professor of Entomology.

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FARMERS' INSTITUTES UNDER THE AUSPICES OF THE UNIVERSITY.

To E. W. HILGARD, *Professor of Agriculture:*

SIR: Ever since the establishment of the University, the members of the teaching staff of the College of Agriculture have participated in the proceedings of societies and conventions devoted to agricultural progress and the dissemination of agricultural information. Such association with practical agriculturists has secured important results. It has brought the institution and its purposes directly to the attention of those whom it aims to benefit, and has won their interest and support; it has assisted the members of the college staff by increasing their knowledge of agricultural conditions and needs; it has also, to some extent at least, given the staff opportunity to observe the natural resources and characteristics of the State, which is indispensable to any adequate knowledge of the industrial adaptations of the region. It has been regretted that field work and local investigation have always been sorely restricted by the incessant demands for laboratory and office work at Berkeley, and by the fact also that no funds were provided for this purpose.

Still, as has been intimated, all possible participation in agricultural assemblies has been gladly undertaken, and an opportunity for freer intercourse with the people in their local meetings was welcomed. This opportunity arose with the request from the California State Grange, addressed to the Regents of the University, that Farmers' Institutes be undertaken under the auspices of the University in California, as had already been successfully done in Wisconsin and in other States. At the same time the Morrill Aid Fund became available, and the Regents deemed it fitting that a part of that fund should be used in the form of an extension of the instructional work of the College of Agriculture through the Farmers' Institute method. This action was taken by the Regents in March, 1891, and the beginning of Institute work under that name in this State was in April of that year. The effort has not advanced as rapidly as some of its promoters wished it might, and yet probably as much as was possible under the conditions limiting it. About the same time there arose farmers' movements which necessitated the devotion of much time from those who enlisted in them, and it was impossible to secure satisfactory attendance at Farmers' Institutes while people were so deeply engrossed with more ambitious organizations. Immediately upon the assumption of a quieter phase by the movement referred to, there arose the necessity for reforms in the marketing of some California products, and in nearly all the more progressive regions of the State local organizations for specific purposes, such as coöperation in production and marketing, and the like, were undertaken, and made constant requirements upon the time and spirit of the communities. The holding of Institutes served well in some cases to concentrate local efforts for specific purposes, as, for example, the coöp-

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erative movement for marketing the raisin product of the San Joaquin Valley, began by the appointment of a committee by an Institute meeting held at Fowler; but it must be acknowledged that the active participation of farmers in nearly all localities during the last three years in frequent meetings for specific and imperative purposes has put limitations upon their active promotion of the Institute movement. Under these conditions it is not to be wondered at, perhaps, that the Institute should not advance rapidly in this State. In nearly all States there has been slow progress at first, but in most of them it has been attributed to the fact that the agriculturists were unused to assemblage for purposes pertaining to their own industry, and were slow to learn its benefits. In this State, where frequent meeting of farmers for all such purposes has been common for years, and where the number of local organizations in proportion to the population is far greater than in any other State, the Institute has only slowly commanded attention, because the farmers were already carrying forward so many organized efforts for their own enlightenment and business advancement.

This brief discussion is indulged in to meet any possible question as to why the Institute effort has not advanced more rapidly. Really there is no reason, perhaps, to consider it slow, though one might claim that such a democratic and untrammeled form of meeting, which makes no money requirement of participants and subjects them to no pledges or rules, save those of parliamentary practice, and which opens up to them all the sources of light and encouragement from agricultural science and practice, should be rapid and all-pervading in its command of public attention. It is answer enough to say that nothing of an educational character goes that way. As nearly as I can learn from reading, we have done about as much in three years as most other States have done. We are, in fact, just at the time in our Institute history when rapid progress should commence.

During the last three years Institutes have been held under the auspices of the University as per following statement:

Fresno County	10
Tulare County	3
Placer County	3
Alameda County	3
Sacramento County	1
Sonoma County	1
Los Angeles County	10
Santa Barbara County	2
Ventura County	1
San Bernardino County	1

This is, of course, a very uneven distribution of the Institutes geographically. It is due to the fact that the people in the counties have manifested interest in the work in varying degrees, as the numbers of meetings show, and that all the counties named surpass in interest the other counties of the State. Although my correspondence has covered a much greater list of counties, those named are the only ones which have shown their interest by the preparations which are required for the meetings on the part of the localities desiring them.

To show what requirements are made of localities I quote the following from the instructions for carrying on this work, as adopted by the Board of Regents:

(*a*) That the work proceed somewhat slowly at first, with the expectation that the number of meetings will increase as the people become informed of the character of

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the Institute effort and its influence as a factor in the advancement of practical agriculture. Such has been the history of the work in those States in which the system has reached its best development.

(*b*) That, for a time at least, the work be allowed to proceed in directions which seem to welcome it; or, in other words, that the demand for the work, as shown by application and local preparation for it, shall indicate the direction in which the supply shall proceed. This is not only a natural course for the effort, but is at the same time a surety of local interest and coöperation, without which success is impossible.

(*c*) That it shall be understood that evidence of local interest and coöperation shall consist in local preparation for the meetings. That representatives of local agricultural societies or volunteer committees, or energetic individuals acting singly, shall undertake to arouse local interest, shall secure promises of participation from progressive agriculturists of the region (both men and women when feasible); shall provide suitable places of meeting, and whatever local printing may be desirable, and shall meet whatever expenses shall arise in the carrying out of their own plans.

(*d*) That whenever the officer of the University who is conducting this work shall be assured of trustworthy local interest of this kind, it shall be his duty to render the local participants every possible assistance in planning their meetings and in other preliminary preparations, and either he or some other member of the University staff shall attend in person all meetings which are understood to be held under University auspices.

(*e*) That such meetings, understood to be under University auspices, shall be conducted by the University representative, who shall conduct them under rules usual for the conduct of parliamentary bodies; that all such meetings shall be understood to proceed under the head of "special order," which shall be the improvement of agricultural practice and the education of the people in the sciences underlying it, the improvement of the home and the methods of home life, the advancement of intellectual culture and other matters calculated to render the meetings valuable, entertaining, and profitable, but that all vexed questions of politics, religion, socialism, and the like, shall be considered out of order. This course has been fully approved by Eastern experience with such meetings.

The conditioning of Institute work upon the degree of interest manifested by localities desiring it is in accordance with the best precedents. For example, in the State of Wisconsin, where Institute work has attained the highest excellence and at the same time the greatest popularity, and where the Legislature makes an annual appropriation of $12,000 for its prosecution, it is insisted that the locality shall share the burden and expense of the meetings. I quote the following from a circular issued July 3, 1894, by Geo. McKerrow, Superintendent of the Wisconsin Institutes:

> The University of Wisconsin, wishing to reach as far as possible all the agricultural portions of the State during the coming winter, respectfully asks that all those interested in the holding of Institutes in their respective localities, write the undersigned at Madison, expressing their wishes and stating number of inhabitants in village or town, seating capacity of hall, hotel accommodations, and leading agricultural industry followed in the locality.
>
> The locality asking for a meeting will be expected to furnish a hall properly heated and lighted for a two-days' meeting, and do all the local advertising free of cost to the University, while the University will furnish practical men to open the discussions, and also advertise the meeting to some extent, besides distributing two hundred copies of Bulletin No. 8, and other agricultural reading matter free of cost.
>
> We do not expect to be able to place Institutes at all points requesting them, but all can rest assured that their claim will be carefully considered by the University authorities, and those places where Institutes have never been held, as well as those that have made previous meetings a success, will be favorably considered, as far as possible.

It is evidently no part of a University's enlistment in Institute work to proceed upon the methods of showmen, to hire halls, bill the towns, and pay the expenses of lecturers upon the mere chance that the people will attend. There must be local manifestation of interest enough to show that this phase of University extension will be welcomed and made profitable.

In California, as shown above, this interest has differed widely in degree. In three counties there are local organizations for the express purpose of appointing meetings and securing the necessary local facili-

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ties. Fresno County was first to adopt this plan. Los Angeles County followed this lead, and subsequently the sphere of the organization was enlarged to include all the counties south of the Tehachapi Mountains.

In order to show that the local preparation which is required is not formidable, I quote from a preliminary circular letter which I have used in reply to inquiries as to what it is necessary to do to have an Institute:

First—Be sure that you can rely upon enough people to work with you to succeed in creating popular interest which will bring a good attendance of both men and women to the sessions.

Second—Be sure you have enough speakers or readers of essays, and musicians if possible, to make the meetings both practically valuable and entertaining.

Third—Provide a suitable place of meeting, which shall be bright and comfortable, and not too large. It is better to be a little crowded than to have a small number scattered through a large, dreary hall.

Fourth—You need the sympathy and coöperation of the local newspaper men, so that they will give you good notices of the Institute and help in bringing the people together.

If you conclude you can master these four factors you may count upon success. A good way to determine these points is to call a meeting of all who will work with you in getting up the Institute, and canvass the subject. The programme should include some representation of every kind of farming which is followed in the region you expect to include in your Institute. All these subjects need not be embodied in formal essays or addresses, though as many as possible of them should be, because if a man or woman will write her facts or thoughts the results are apt to be more compact and tangible. But if some say that they "can't write," get them to be present and give their experience in the form of a talk and answers to questions. Get every man or woman in the region who is doing something better than it is generally done, to participate in the meetings. Short statements are better than long ones, and there should be a host of them, so as to touch every one's interest at some point and bring out a large attendance.

There should be some essays or talks from the ladies on home affairs, woman's work in agriculture, floriculture—any feminine subjects which they can present acceptably. The music may be both vocal and instrumental, as far as both can be provided for, and every neighborhood can furnish this either in solo or chorus or both. It helps wonderfully to enliven the meetings.

From this hasty sketch it appears that much work must be done by those in the locality who take an interest in the matter. The University instructs me to be useful in conducting such Institutes, and authorizes me to enlist other lecturers from the faculties of the University who may be disposed to participate, and pays all expenses of the University representatives. The expense of local arrangements are borne by the locality. Sometimes by the use of a church or schoolhouse (during vacation) and by securing the good will of the local newspapers, it is possible to have very good meetings with very little expense.

In the prosecution of the Institute work thus far I have attended meetings in all of the counties named above, and have visited some of the counties several times. Professor Hilgard has prepared special addresses for at least five Institutes. President Kellogg, Assistant Professor Woodworth, Mr. M. E. Jaffa, and Mr. A. P. Hayne have also participated in the meetings. It must be acknowledged that sometimes the requirements of the work are arduous, and occupy time which cannot be well spared from other University duties. The importance of it to the University and to the public is, however, unquestionable. In the future it will be necessary to engage assistance from qualified speakers outside of the University staff, as is the practice in other States where the work has attained large proportions. The measure of this help, and in fact of the movement as a whole, must depend upon the degree of interest which may be awakened.

The character of the meetings held thus far has been eminently satisfactory. The attendance has varied greatly, ranging from 50 to 200. In every case sharp interest has been manifested, and many resolutions have been adopted approving the effort on the part of the University. There has also been a very gratifying spirit displayed in contributing to the success of the meetings in the way of essays, addresses, and free

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participation in the discussions which have arisen. A file has been kept of the matters of greatest interest which have been presented, so that an extended report of the Institute proceedings can be prepared for publication if arrangements should be made for it. It is very desirable that such report should be provided for. In this way a far greater distribution of the benefits of the effort could be secured and wider interest aroused. It is customary in other States to provide for such publication.

EDWARD J. WICKSON,
Associate Professor, in charge of Farmers' Institutes.

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REPORT OF OBSERVATIONS MADE ON EUROPEAN AGRICULTURAL SCHOOLS AND EXPERIMENT STATIONS, 1892-93.

By E. W. HILGARD.

To the President of the University:

As stated in my application for leave of absence, it was my intention to combine with a year's travel in Europe, systematic observations on the agricultural schools and experiment stations of the continent, to be embodied in a report on my return. My plans in this direction were unfortunately very materially curtailed by the health conditions of my family and other circumstances beyond my control, which forbade extended travel and compelled more prolonged residence in single localities. As a consequence, my observations have been less varied than I could have wished, but made me thoroughly acquainted with a few of the most prominent institutions and with the general facts relating to the system; it is with these, therefore, that this brief report mainly deals. I propose, however, to continue and extend the study of the subject, for embodiment in future reports. Thus far my observations have borne mainly upon Germany, Switzerland, and France. But the brevity of time at my command constrains me to defer my remarks on the latter country to a future time.

GERMANY.

General Condition of Agricultural Education.—As a consequence of the minute political subdivisions that have existed in Germany in the past, the distribution as well as the organization of agricultural instruction and experimentation is not uniform over the various portions of the country. The establishment of the empire is of too recent date, and "particularism" is still too potent in some regions, to permit the more perfect unification of plans and methods that in some respects would be very desirable. Prussia presents in this respect more of a uniform organization than the other States of the empire, and may be most usefully studied.

Historically, schools of forestry have preceded those of agriculture proper. Forestry has from the outset held, in the estimation of the governing classes, a position materially higher than the pursuit of the peasantry; largely from its intimate connection with the "noble art of venerie," which was and is now deemed a worthy occupation for kings and nobles; it is only in China that the tillage of the soil is considered worthy of imperial hands. Trained foresters were needed, and hence training schools were established for them in various forms, in early times. It seems also to have been the failure of the old system of husbandry to produce satisfactory results on the royal "domaines" and on the large estates of the nobility, that first attracted governmental attention to the need of agricultural training-schools for the managers of these establishments, so as to make the latter maintain their accustomed incomes.

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As the agricultural production of all countries has gradually come into competition in the world's market in consequence of the increased facility of intercommunication, the maintenance of these incomes at the point required for the accustomed high living of the proprietors has become more and more difficult, and has even resulted in the formation of an "agrarian party," whose programme is the "relief f the agricultural depression," by measures among which the partial repudiation or scaling-down of mortgages on landed properties is freely discussed. The only true mode of relief lies, of course, in the scaling-down of the former style of living on the part of the proprietors themselves, and in their personal participation in the task of bringing the methods of culture and production up to the highest level rendered possible by modern agricultural science and practice.

There is thus a demand for well-trained men to serve as managers of large landed estates and royal "domaines"; the more advanced members of the landed nobility, as well as the large landed proprietors not within that privileged class, also desire similar training for their sons. For these, of course, the most thorough scientific and practical training is needed; and it is from this class that the students of the agricultural colleges proper are most largely recruited. Another portion aims at employment as teachers in the lower schools of agriculture, and as lecturers ("*Wanderlehrer*") at what in the United States is now known as Farmers' Institutes. The numerous experiment stations, also, require a not inconsiderable number of men of similar training. Finally, the official land surveyors for the rural districts form an additional contingent. The training of these men falls mainly within the province of the university grade of agricultural schools, most of which are either integral parts of, or more or less intimately connected with, the universities. Such is the case, in Prussia, with the agricultural institutions at Berlin, Königsberg, Breslau, Halle, Kiel, and Bonn (Poppelsdorf); in Saxony, with the University of Leipzig; in Bavaria, with that of Munich. In all these, university professors form part of the faculty of the agricultural colleges proper, and vice versa; while students are admitted under one matriculation to the lectures of either. These facts are specially commended to the attention of those who, either from the standpoint of the old-school "humanities," or from that of the populist agrarian, would have the agricultural colleges of this country detached from the State universities.

Besides these agricultural colleges forming university departments, and embracing all branches of agriculture, there are a number of special schools, still of the university grade, but to a certain extent the outgrowth of local needs. Of these the forestry schools have already been mentioned (in Prussia, Eberswalde, and Minden); the veterinary colleges at Berlin and Hanover rank in the same category.

Most of these colleges have prescribed two- or three-year courses for those aspiring to government employ in the several branches. Coming as they usually do from the gymnasiums and "realschulen," they enter approximately with the preparation reached with us at the end of the sophomore year.

On a lower plane, and designed for the use of the middle and peasant classes, are two grades of agricultural schools scattered as yet too thinly and unevenly over the country. Of these, the higher grade may, on the literary side, be taken as representing the grade of our preparatory col-

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leges; they teach not only the practice of agriculture, but also give short but systematic courses in the underlying sciences. They stand in a measure in place of the secondary schools for those who intend to pursue agriculture as a calling. In the school of Meissen, in Saxony, which may serve as a good representative of this class, the course consists of two half-year terms, and includes geometry, surveying, and drawing, besides elementary courses in botany, geology, general and as related to soils, agricultural chemistry, and physics, practical agriculture and horticulture, and stock-breeding; also national economy and legislation, and bookkeeping. The shortness of the course indicates the very elementary treatment of all these topics; but the Meissen school is well attended by the sons of small proprietors, and evidently fulfills a needed function in that portion of the country. There is room for a great many more of the same kind, but the system as a whole is as yet only in its beginnings.

The lowest grade of agricultural schools—distinguished as "land-culture schools" (*ackerbauschulen*), or locally as peasant schools, from the higher grade—are altogether elementary in their teaching, agriculture practice being the main point aimed at, and as such of course adapted to local needs; while on the literary side the grade is that of an American grammar school.

Whether this last grade of schools would be successful in America, where class distinctions are not recognized, I consider very doubtful; but I think some of the methods and subjects of instruction could be very properly and usefully engrafted upon our secondary schools, especially in the rural districts.

There are also some separate "*winter schools*" that give short courses, usually of special instruction on some locally important practical subjects; very much as is done in some of our American agricultural colleges, though here commonly on a higher plane.

The instruction given by *traveling teachers* in the rural districts differs in no essential point from that connected with our Farmers' Institutes; only the more complex government machinery is called into action in connection with the officially recognized agricultural societies, district fairs, and other occasions of public interest, to bring together the audiences. The extent to which this mode of diffusing progressive ideas in agriculture is practiced varies very greatly in different portions of the country, as does also, naturally, the more or less elementary treatment of the subject, according to the degree of advancement of education and agriculture in each district.

The *Agricultural Experiment Stations of Germany*, intimately connected as they are with agricultural progress, are mostly unconnected with educational institutions proper. The latter are, however, throughout more or less engaged in experimental and other original work, which is there expected of every teacher of the higher grades, and to a very large extent forms the gauge of his advancement, and of the estimation in which he is held.

The experiment stations proper are not all organized on a uniform plan or for a uniform purpose; their functions conform in a large degree to local demand and requirements, as a consequence of the fact that many of them are dependent upon the district agricultural societies, from whom they receive a portion of the subsidies granted to these societies by the Government. The analysis of fertilizers forms a large proportion of the work of most of the general stations; and as, strange to say,

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there exists no governmental control of the fertilizer trade, this work is of the utmost importance and is, of course, foremost among the services required of the stations by the district societies. Unquestionably, the American system of State experiment stations as part of a great system centering in the Department of Agriculture at Washington, is very far in advance, *as a system*, of the uncertain tenure by which most of the German stations hold their incomes and organization. Practically, however, their work is largely systematized and unified by the existence of the general association of experiment stations (*Verband der Versuchsstationen*), at the annual (migratory) meetings of which the station men come together to compare notes and unify by agreement both methods and subjects of investigation. The comparatively uniform climate of the country embraced by this association renders such agreements much more easy than is the case in a country of the enormous extent of the United States, where climatic, cultural, and commercial conditions are so varied as to render such uniformity both impossible and undesirable. Having had the advantage of being present at, and participating in, one of these annual meetings at Berlin, I was forcibly impressed with this difference as compared with the corresponding meetings of the American Association of Experiment Stations.

Outside of these officially established institutions for instruction, experimentation, and research in agriculture, there is one potent factor through which they are kept in constant touch with the progressive elements of agricultural population. This factor is the Agricultural Association of Germany (*Deutsche Landwirthschaftliche Gesellschaft*), which in a measure corresponds to a "State Agricultural Society" in its functions, since besides the membership fees it receives more or less of government subsidies, mostly for specific purposes. Its meetings are partly migratory, as are, likewise, the general expositions or fairs held under its auspices. There is, however, one central meeting held annually at Berlin, during a week toward the middle of February, which is known as the "great agricultural week," and which is attended not only by members of the society, but is a rallying point for all who desire to discuss agricultural interests. The deliberations and decisions of this week form a not inconsiderable factor in the programme of the year, and have material influence in commercial and political circles. The quasi-official organ of the society is the *Deutsche Landwirthschaftliche Presse*, a semi-weekly paper, standing at the head of popular agricultural journalism in Germany, and the medium of communication and discussion not only between practical agriculturists, but even between scientific investigators whose researches have direct bearing upon practice. The prominence of this paper insures the widest publicity for everything published in its columns, throughout the German-speaking countries.

In further elucidation of the subject, I give below detailed descriptions of a few of the prominent institutions of Germany.

THE AGRICULTURAL COLLEGE* OF PRUSSIA.

Among the agricultural colleges of Germany probably that of Prussia, at Berlin, may be considered the typical and most complete one in its development and final organization.

* Its official designation is "Landwirthschaftliche Hochschule"; literally, "high school," but in German usage signifying an institution of the university grade, and sometimes a university itself.

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Its first beginnings date back to the year 1806, when Albrecht Thaer, the "father of rational agriculture in Germany," established the first "academic school of agriculture" in Germany, at Möglin, in the neighborhood of Berlin, under the special patronage of the King of Prussia. When, a few years after, the University of Berlin was established, the agricultural school was transferred to it as a department, Thaer being appointed Professor of Agriculture at the University. But as agricultural science was then in its infancy and Thaer found it necessary to employ, in the main, practical demonstration in his teaching, he subsequently resigned the university professorship and returned to the "model farm" outside of the city. This institution, however, retained its connection with the university and served for the practical studies of those who in the service of the State required a knowledge of agriculture.

With the development of agricultural science during the first half of the century, it soon became apparent that in order that the instruction at Möglin might keep pace with such advances, it would become necessary to restore more intimate connection of agricultural instruction with the university, where ample provision for the study of the fundamental sciences already existed. Formal reports to that effect were made in 1849, but encountered many practical difficulties; until in the early sixties the agricultural institute at Möglin was definitively closed, and an agricultural department was reëstablished at the university.

For some time its development was greatly hampered by lack of room and appropriate buildings, especially for the rapidly accumulating collections, and for the laboratories for advanced students, for which no provision could be made in the university buildings. In 1876 the construction of a large building specially designed for the agricultural department (which was then given the title of "Landwirthschaftliche Hochschule" or agricultural university) was begun, and in 1881 the various branches of instruction and the museum were transferred to the joint occupancy of the new building.

This building is of brick, with stone basement; dimensions, 188 by 240 feet, and three stories high. In its central portion is a quadrangle covered by a glass roof, 147 by 60 feet, "Machinery Hall," which is specially reserved for the display of agricultural implements and machinery, partly "life-size," partly in the form of models. In the latter category there is of plows alone a collection of several hundred numbers. The zoölogical collections, the institute of animal physiology, and administrative offices occupy the rest of the lower floor or basement.

The second floor is also mainly occupied by collections, among which that of vegetable products and models of fruits, flowers, etc., of cultivated plants of the whole world is so extensive that a special guide and catalogue of eighty-four pages has been issued to facilitate its use. It occupies completely one of the longer sides of the building. An extensive collection of soils and soil-forming rocks and minerals of the kingdom occupies one of the ends of the building, while collections illustrating all branches of agricultural production and manufactures, and fresh-water fishes, together with a collection of beautifully constructed models of buildings for all of these purposes and industries, fill the remainder of this floor.

On the third floor are located the greater part of the lecture-rooms,

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laboratories, and work-rooms of the professors and assistants. Here are separate laboratories for botany, vegetable and animal physiology, agricultural chemistry, physics, and surveying; together with an extensive library representing all these branches of science.

Attached to this building, but not properly forming a part of it, is a one-story structure, 92 by 30 feet, containing the general chemical laboratory, where the agricultural students can obtain the needful preparation in general and analytical chemistry; also the special laboratory for investigations in the beet-sugar industry. A tall chimney-stack serves for ventilation as well as for fire-flues.

The total cost of the main college building and equipment, exclusive of collections, has been $632,000 up to 1893.

The faculty of the institution consists of fourteen full professors, sixteen regular assistants, and fifteen "privatdocenten" (instructors compensated only by the fees of students) teaching special branches; forty-five in all. The museums of the several departments are under the direct supervision of their respective professors and their assistants, aided by the janitors.

The branches covered severally by the full professorships are the following—each subject being taught with a special view to its bearing on agriculture: Physics; mineralogy, geology, and pedology (soil study); general chemistry; agricultural chemistry; general (structural and physiogical) botany; agricultural or economic botany; practical agriculture (two professors teaching distinct branches); mathematics; surveying; animal physiology; zoölogy; political and economic science.

The assistants in most cases give instruction in subdivisions of the subjects taught by their chiefs. The "privatdocenten," however, teach a number of specialties, the more extended study of which is provided for in separate institutions. Thus it will be noted that veterinary science and forestry are not represented in the above list of subjects; the reason for this is that there exists in the city of Berlin a large special school of veterinary science, located not very far from the agricultural college, but not directly connected with it, though subject to the same governing body, at the head of which stands the Minister of Agriculture. It is at this special school that veterinary surgeons are educated; while merely such general knowledge as every farmer should possess is imparted by the instructor in the agricultural college, whose work is supplemented by a special instructor in horseshoeing. There is an instructor in forestry; but several special forestry schools exist in Prussia, and to these most of the students making forestry their specialty usually go, sometimes after "absolving" their course at the agricultural college. The latter also has an instructor in economic entomology; one for agricultural engineering and buildings; one for agricultural machinery; two for agricultural technology (sugar-making, brewing, wine-making, etc.); a specialist for the anatomy of domestic animals, etc.

Several of the full professors also give instruction in the university; and the terms of all these institutions are arranged to accord with those of the university.

The requirements for admission to the regular course are specified to be those "entitling the applicant to a reduction of the military service from three years to one year"; meaning, in general, that the course in a gymnasium (high school) has been "absolved," so that the student

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would be ready to be admitted to the university in such standing as would qualify him for entering the government service thereafter. There are liberal provisions for the admission of special students and of "hospitants" or visitors. Students admitted to the agricultural college are entitled to attend the university lectures and those of the veterinary and technical institutes without special matriculation.

There is no general graduate degree and no particular time is prescribed for the conclusion of the course, which the student may choose from the subjects taught, according to his particular views or requirements. There are, however, special courses, mostly of two years, leading to definite degrees or certificates admitting the holder to government employ in that specialty. Thus there is a definite prescription for land surveyors, which includes a practical course of one year; a geodetic cultural course of four semesters, for agricultural engineers; and several others leading to definite branches of agricultural practice.

A general fee of 100 marks ($25) per semester admits to all the lectures of the college; laboratory fees range from 10 to 20 marks per semester (or twice that for the year's session of two semesters). Remission of fees in certain cases is provided for; there are also three annual prizes of 150 marks for the best theses on each of the three fundamental branches—agriculture proper, the underlying sciences, and agricultural engineering. A "traveling stipend" of 1,500 marks is also allotted to the best student of the year, recommended as such by the faculty. The student thus endowed obligates himself to carry out a tour of observation, within Prussia or elsewhere, for the study of some agricultural specialty, upon which he reports on his return.

An experimental culture-station of about twelve acres, just outside of the city, has been provided by the Government and placed at the disposal of the agricultural college. It is provided with the necessary farm buildings, together with a small but well-equipped brewery, designed for experiment as well as for practical instruction and actual production. This establishment was originally founded under the auspices of a society having for its object the improvement of the brewing industry, together with instruction in the same; hence, one portion of it is run on a commercial basis, striving, however, to produce a typically good beverage and to test and utilize in practice the indications of the experimental work.

Under a somewhat similar arrangement the college superintends and utilizes for instruction and experimentation an "Institute for the fermentation industries and for starch manufacture," originated and maintained at an annual cost of about 250,000 marks ($62,500), by three industrial societies.

Twenty-two instructors and superintendents are employed in these two practical schools, which are numerously attended; 83 students having taken part in the summer semester of 1891, in the brewery course alone, while 56 attended the instruction in distilling and starch manufacture. The director of these institutes is a member of the college faculty.

THE AGRICULTURAL COLLEGE OF BAVARIA.

The agricultural college of Bavaria is not, like that of Prussia, officially connected with the University at Munich, but forms part of the "Technical University" (*Hochschule*) under a governing board distinct

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from that of the university proper. This institution comprises very nearly the same courses and subdivisions now forming the "technical colleges" of the University of California, viz.: Civil Engineering, Agricultural Engineering, Architecture, Mechanical Engineering, Chemical Technology, Agriculture in all its branches. As in the case of the "Morrill Act," "other classical and scientific studies" are provided for, partly in the technical university itself, partly by the opening of any of the courses of the Munich University to the students. Several of the professors also belong to both institutions. Oddly enough, the School of Forestry forms an integral part of the old university and is located in the university buildings, and its distinguished director, Professor Ebermayer, gives the special courses on soil chemistry for both institutions. On investigating the cause of the retention of the forestry school with the old university, I learned that forestry being nearly related to the hunters' noble art, was deemed of sufficient dignity to be associated with the literary departments; but the old-school university men and nobles drew the line at that and declined to have the technical institution form a part of the time-honored University of Munich. This is the more curious, as that institution was for many years the headquarters of agricultural chemistry under the influence of Justus von Liebig, and to-day confers the Liebig medal "for services rendered to agriculture."

Although the agricultural college of Bavaria is thus considerably younger in age than that of Prussia, and has not yet succeeded in obtaining the needful new buildings for its better accommodation, it is well equipped and several of its professors have rendered distinguished services to the progress of agriculture.

As in the case of the Prussian college, students of the technical university may attend courses at the University of Munich and at the (here also separate) veterinary college.

The central experiment station of Bavaria forms part of the agricultural college at Munich, and its officers are teachers as well. There is a special department for fermentation industries, in which, as may be supposed, all that has a bearing upon the brewing industry receives particular attention.

THE GERMAN EXPERIMENT STATIONS.

As an exemplification of the organization and mode of work of the German experiment stations, I give the following account, condensed from a detailed report made in 1892 on the Halle station by its distinguished director, Professor Maerker, who may be considered as standing at the head of experiment station work in Germany.

The building, now stated to be far too small for the operations of the station, consists of a main building of three stories, 50 by 100 feet, with an L about 40 by 117 feet. The cost of these was $50,000; inside equipment, $12,500.

The staff of the station consists of the director, assistant director, ten chemists, two botanists, two gardeners, a secretary, an accountant, and five janitors who, apart from the care of the building, do the rough work of the laboratories. There are thus twenty-three persons regularly employed. The demand for work, however, was of late found to be so heavy that it became necessary to refer a part of it to the sub-station at Magdeburg. The main station reports that in 1891 the number of

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analyses and other examinations reported upon was 7,311; at Magdeburg sub-station, 2,544; nearly half being analyses of fertilizers and soils.

The total cost of operations in the same year was 65,000 marks, or about $18,250. Of this sum 9,000 marks was supplied directly by the State (Prussia), 3,000 by the provincial treasury, 40,000 from fees for analyses and other examinations, and 13,000 from various sources.

The same remarks regarding the rapidly increasing demand for (mostly chemical) examinations of agricultural materials and products come from many of the twenty-one stations of Prussia. The Bonn station reports for 1893 a total of 5,374 samples sent in for examination, of which 70 per cent were fertilizers and 18 per cent feed stuffs. In 1891, only 3,657 samples were sent in, showing an increase of nearly 50 per cent in two years.

These data, which might be multiplied indefinitely, speak volumes in respect to the great and rapidly increasing appreciation of experiment station work among the practical men interested in agriculture. They are a telling comment upon the cavilers who, in our country, still question the value and need of similar work on the part of the experiment stations. It will be noted that fees are charged for the examinations of fertilizers, which in the majority of our States are made gratuitously (so far as those directly interested are concerned) by the State fertilizer control stations; which may or may not be connected directly with the experiment stations. Here in most cases the expense is defrayed by a license for the sale of the fertilizers, which in the end is of course paid by the users of the latter. But the cost is thus so thinly distributed that it is barely felt, and cannot count in comparison with the benefit derived by the farmers from the State control of this very tricky kind of merchandise. I was struck with the comment made on our practice in this respect by a high official of the Prussian Ministry of Agriculture, to the effect that "the Draconian laws of our States regarding fertilizers seemed somewhat in contradiction to our boasted liberty." My reply was that as with us the public good is the supreme law, the public submits to the needful restrictions of individual liberty, even when these restrictions savor somewhat of paternalism.

Aside, however, from these examinations of samples sent in from outside sources, the German experiment stations pursue steadily the investigation of important questions connected with the theory and practice of agriculture, to the fullest extent that their means permit.

SWITZERLAND.

Since the chief agricultural industry of Switzerland is dairying, its agricultural schools are naturally directed mainly toward the promotion of this branch; and the times and places of giving instruction are in a measure controlled by this consideration.

At the head of technical instruction of all kinds in Switzerland stands the "Polytechnicum" at Zurich; and here also is the general agricultural school of the commonwealth, of university grade. As in Bavaria, the polytechnic school is not officially connected with the university; it is moreover a federal institution, while the university is a cantonal one.

A number of agricultural schools of second and third grade exist in the republic; but a specially prominent feature are the winter schools,

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since it is only in winter that those who exercise the dairy industry can ordinarily attend. Such schools are usually located at the cantonal capitals; and their courses begin when the cessation of the influx of tourists sets the population free to think of their own affairs, and the snow drives both the cattle and their attendants from the mountains to the valleys.

Experiment stations also exist in several of the cantons; and one of the culture stations visited by me—on the Rigi Scheideck, at an elevation of nearly 5,000 feet—proved that much yet remains to be done in that line even in so old a country. Potatoes matured, and good crops of rye and several of the hardier pasture grasses grew at this elevation, where a week's snow storm during the month of August is a common experience, as in fact it was in my case. The snow simply bore down the potato vines and grasses, as the temperature hardly fell below the freezing point; and a week after it would have been difficult to tell that anything had happened to interrupt the summer weather. It thus behooves us to test similarly the agricultural capabilities of our higher altitudes; particularly where, as in the Coast Range, the ocean serves to temper the extremes of temperature materially, both in winter and summer. In the Coast Range, Mount Hamilton invites the location of a station corresponding to that on the Rigi.

GENERAL CONCLUSIONS.

Equipment and Attendance.—One point that strikes the American observer most forcibly in these German institutions, is the abundant provision made everywhere for the tangible illustration of whatever is taught. In the building of the agricultural college of Prussia the space occupied by the museums and illustrative collections exceeds considerably that allotted to the direct process of instruction, two out of the three floors being given to collections, while even on the third floor laboratories predominate over lecture-rooms. While this is rather contrary to the traditional ideas of the dreamy, unpractical tendency of the German, it is entirely in accord with the magnificent showing of industrial progress made by Germany at the Columbian World's Fair; and in this connection the fact mentioned above, that industrial societies have actually founded, and are now defraying the expenses of, industrial schools, which they have then placed under the direction of the college of agriculture, is not less significant. It is in line, too, with the employment by the great chemical manufactories, of hundreds of chemists, whose sole duty is to make investigations tending to discover or improve processes for the manufacture of commercially available products. These facts convey lessons needed even in practical and progressive America, where there is still constant cavil anent the propriety of State aid to education above the grammar grade, and where the practical utility of experiment stations is still deemed a debatable question on which demagogues may hope to acquire a cheap popularity by favoring their abolition. In Germany, so far from this, many of the experiment stations, as stated above, have been founded and are now wholly or in part maintained by local or provincial agricultural societies, usually with some aid from the governments, given through these societies. They and the agricultural colleges are the universally recognized leaders of progress in agriculture, and to them all questions arising in practice are referred.

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The meager equipment both in the way of illustrative collections and working facilities that exist at most of our agricultural colleges and experiment stations is peculiarly disadvantageous and inappropriate in a country where a demand for instruction of a "practical" character is maintained with such peculiar loudness and persistency. That this scanty equipment stands essentially in the way of the attractiveness of the agricultural courses to students, not to speak of efficient teaching, is too obvious to require extended comment.

This brings up the question of attendance, which is, more or less, a sore point with the university-grade agricultural colleges of the United States. I have repeatedly endeavored by analysis of the courses and occupations pursued by the students of the corresponding German colleges, to obtain figures by which a fair comparison with those attending American colleges could be made. While unsuccessful in obtaining detailed data, for lack of records, the following considerations are of interest in this connection:

The total annual attendance upon the courses of the Agricultural College of Prussia, at Berlin, is about 400. Of these, approximately half belong to the courses of surveying and agricultural engineering. Of the remaining 200 a not inconsiderable proportion are students taking partial courses in agriculture, while properly belonging to the class of "cameralists," that is, young men aiming at government employment in rural districts as clerks, accountants, and judicial, as well as fiscal officers, of whom a certain familiarity with the details of agriculture is required in examination. The rest, say not exceeding 150, are the agricultural students proper of the classes heretofore enumerated, to wit: those aiming to be managers of large estates, whether of the crown or private, partly as employés, partly as the heirs of the proprietors.

It will be noted that this very numerous class of students is directly dependent upon and connected with conditions, industrial and social, but scantily represented in the United States; hence, the contingent so supplied must be deducted from the credit for attendance given the institution; together with that pertaining to the engineering courses, already referred to. We are thus brought to the conclusion that in Europe, as well as in America, the attendance of farmers proper upon the State college of university grade is not at all large, considering the fact that farming without fertilization and rotation, etc., is an unknown quantity in these old countries, and that it is only universal tradition that maintains a fairly remunerative husbandry among the peasantry.

At the agricultural college of Bavaria the classes in agriculture and agricultural chemistry average about 40 only; alongside of these the classes in forestry and engineering average over 100 each.

In the schools of the second grade the roll shows very uniformly the designation of the students' parents as "land-owners" (*gutsbesitzer*), with the obvious implication that their sons will be their successors in the same occupation of a well-to-do farmer.

In view of all these facts I can but repeat my opinion frequently expressed heretofore that so long as our soils remain productive without imperative need of fertilization, rotation, etc., to insure remunerative crops, the attendance at our colleges of bona fide farmers' sons intending to return to the farm will remain comparatively slight; but as soon as the shoe begins to pinch, and intelligent and frugal husbandry

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becomes a necessity, our agricultural colleges and schools will receive a correspondingly increased attendance. The beginning of such a movement is already seen in the attendance, as special students, of those often of mature age, who intend to engage in agricultural branches requiring professional information, training for observation, and educated judgment.

GENERAL RETROSPECT.

Reviewing briefly the general aspects of agricultural education in Germany, we find that in all cases there is at the head of the system one or more departments or colleges of university grade, which educate both the teachers for the institutions of the lower grades, and the agricultural experts that are to stand at the head of large estates and thus lead the van of agricultural progress in practice. To me this appears to be a logically necessary function, the very condition precedent of any rational agricultural education whatever. Yet this has been one of the most bitterly contested points in this country, so that in many States the attempt has been to make all agricultural instruction mainly "practical," even when only a single institution could be established on the basis of the available funds. I think experience has shown that this is an error; that instruction of the highest grade for the education of the leaders of progress is the true function of a State college of agriculture. For in almost every case the colleges whose curriculum was organized on the popular "practical" plan, have, in the course of time, been compelled to raise the standards to a higher plane, with an obvious tendency to place them on a university grade. To discuss the propriety or relative advantage of the organic connection of the agricultural college with the literary and scientific university would carry me beyond the limits of this report. But I cannot reconcile myself to the thought of the official and permanent recognition, as a factor in shaping our educational policy, of the snobbishness which looks down upon agriculture as a vocation of inferior degree. It is truly remarkable that in republican America prejudices should be allowed a foothold which even in monarchical Germany dare not show their face. The strong and influential representation of the agricultural element in the German Reichstag stands in marked contrast to the manner in which the farmers' interests are made to take a "back seat" in our legislative assemblies; not so much because farmers are not there, but rather because for lack of training they cannot make themselves felt as against their well-equipped competitors of the politico-legal profession. It is only by a correspondingly thorough training, connected with their own pursuit, that this state of things can be remedied.

It is evident that it will be long before the mass of farmers will take such a higher course of education, even if it were possible to accommodate the rank and file in the State Agricultural College. There are substantially two plans upon which such instruction in the principles of agriculture, as it is possible to impart within the limited time usually at the disposal of farmers' sons, can be imparted. One is the plan adopted by Germany, of separate institutions on a lower plane than the State College, standing substantially in the place of the high school for those who do not desire the latter kind of education. The other is the system adopted by France, of making instruction in agriculture run parallel with the other grades

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and subjects of education, throughout the public school course, in rural districts.

The latter plan would in this country encounter almost insuperable difficulties at the present time, in the lack of qualifications for such instruction on the part of common-school teachers, which is not likely to be remedied within any short space of time. Moreover, it is apt to load down too much the already crowded curriculum of the schools, curtailing still further the time for needful general culture. In my view, however, the establishment of a sufficient number of schools corresponding to the second grade of the Prussian system and provided with specially qualified teachers, would be the appropriate course to be pursued in giving a proper and sufficient opportunity for professional education in response to the demand of the progressive portion of the farming population who desire to retain their sons within their own immediate sphere of influence in the rural districts, while still enabling them to avail themselves of the advantages of rational agriculture.

It may be said that this would still further enhance the already heavy burden imposed upon taxpayers for the maintenance of the public schools. To this I reply that it is difficult to imagine a more important duty in the life of parents than the proper education of their children in their life pursuits; and that their duty to them can hardly be considered as fulfilled by the payment of the traditional $10 to $15 per annum "per census child." There are a great number of other subjects of expenditure which they can better afford to cut short; and it is certain that without such additional provision for the better education of the farming population in their pursuit, the State colleges are powerless to bring about the desired result.

The trade schools now being established at many points in the United States, and of which two will belong to San Francisco, while one may be established in close connection with the University, seem to point the way in which the desired solution for the problem of secondary education for the farming population lies. There is, however, one essential difference, inherent in the nature of the case, to wit: that while in trade schools the acquisition of manual dexterity or "handicraft" plays a prominent part, while instruction in principles may be quite simple and rudimentary: in the farmer's pursuit the handicraft is so readily acquired that most boys attain it more or less perfectly on the home farm by daily practice, while the *principles* upon which the operations of the farm must be based to secure the best results are the main thing needful to be acquired in the school, and unfortunately these principles are very complex, and farm practice must be materially modified according to local conditions. Hence it is that "model farms" can rarely represent more than the best local practice, which will mislead the learner when applied elsewhere. This, in a country where the population is so large and varied, and is so continually on the move, renders necessary a higher grade of instruction than that which is given in the second-grade schools of Europe. The growth of such schools must almost necessarily be slow on this account alone; for the teachers qualified for such instruction, embracing both theory and practice in a nutshell, have still to be educated.

While not strictly within the programme of this report, it may not be inappropriate or irrelevant to state my experience in regard to the ideas

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entertained concerning this State by those with whom my inquiries brought me in contact. The facts in the premises may be summed up in the statement, that the almost universal impression as to the natural capabilities and social conditions of California were those conveyed in the writings of Mark Twain and Bret Harte, which are very generally known and read. While some few as travelers, geographers, or business men had had occasion to become acquainted with California as it is, yet the statement that it is now preëminently an agricultural State met with considerable incredulity even on the part of university men and high officials who knew a great deal more about Mashonaland and Central Africa than California. Thus it happened that I was repeatedly called upon to deliver lectures on California topics before scientific societies at Berlin; and it was characteristic of the slight interest usually bestowed upon the Pacific Coast, that it was impossible to procure in the city of Berlin any map of this section that could serve for lecture purposes; so that in one case I had to draw one on a blackboard; in another—that of the Geographical Society—a special (rainfall) map was prepared for the purpose, and distributed to the audience, in order to illustrate the paper properly. The printing of this and other lectures in the proceedings of the respective societies was especially opportune, in that it induced a number of persons who intended to visit the Columbian Exposition to extend their travels to this coast; so that I had the pleasure of welcoming to Berkeley during the past season, quite a number of gentlemen who were among my audiences at the Prussian capital.* Among other visitors whose interest had been aroused by the republication in the German language of Bulletin No. 3 of the U. S. Weather Bureau ("On the Relations of Soil to Climate," 1892) were two Hungarian agricultural engineers, who desired to look into the subject of the reclamation of alkali soils to which I had called the attention of the ministry of agriculture of that country, since vast tracts of similar lands exist in the valley of the Theiss. I subsequently received a request from the ministry to forward samples of Californian alkali soils for comparison with those of Hungary; which has since been complied with.

One of the results of these visits has since become apparent in the appearance of a number of reports and articles on the agriculture of California and the Pacific Coast at large, which have appeared partly in official form, partly in various periodicals, notably in the *Deutsche Landwirthschaftliche Presse* of Berlin, already mentioned above. Among these an extended series by Professor Backhaus, of the University of Gottingen, deserves special mention for its completeness and fairness.

In Paris the experience of Berlin was repeated, in lectures delivered by request before the Agricultural Society of France, as well as the Société d'Acclimatation at Paris. Besides these lectures, which were

*Among these visitors were the following: Dr. Emil Schmidt, Imperial Councillor of State, Russia; Professor Maercker, Director of the Government Experiment Station at Halle, Germany; Dr. Carl Thiel, Chief of the Department of Agriculture of Prussia and Councillor of State; Dr. Wittmack, Professor of Economic Botany in the Agricultural College of Prussia, Berlin; Dr. Alexander Backhaus, Professor of Agriculture in the University of Gottingen; John Bolle, Director of the South Austrian Experiment Station and President of the Agricultural Society of Austria; Dr. Hans Solereder, of the Botanical Department of the University of Munich; John Telesky, Attaché of the Hungarian Ministry of Finance; Major P. G. Craigie, Director of Statistical Branch, Board of Agriculture, London; M. Henri Vilmorin, Secretary of the Agricultural Society of France; Professor Lunge, of the Polytechnic Institute of Switzerland, Zurich; Dr. Gust. Retzius, Professor of Geology, University of Stockholm; David Golownin, Civil Engineer, St. Petersburg; Louis Landau, Royal Engineers, Hungary.

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printed in the transactions of these societies, a French translation of the bulletin on "Climate and Soils" has since been published in "Annales de la Science Agronomique," the official report of experiment station work. Thus our relations, exchanges, and correspondence with agricultural scientific centers abroad have been materially extended; and much valuable material is constantly coming to us that in the ordinary course of events would not have reached us until it was antiquated, if at all.

I may thus hope that even from a purely utilitarian standpoint, my year's vacation has not been without permanent benefit to the State and to the University.

E. W. HILGARD.

JUNE, 1894.

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THE WORK OF AMERICAN EXPERIMENT STATIONS.

By E. W. Hilgard.

[This brief statement of views upon some of the features of the work of the American Experiment Stations was originally prepared for "Garden and Forest," and it is reproduced in this place in the hope that it may contribute something to a general understanding of the scope and purposes of station work.—E. W. H.]

The occasional expressions of dissatisfaction with the work of our Experiment Stations are symptoms which it is desirable should be met by a careful diagnosis and rational treatment, to prevent their developing into a form which might bring serious trouble to the system of which as such, we may justly be proud.

For, the organization of the American stations is undoubtedly much better calculated to bring about unity of action and parallel work than is the case in the German stations, so many of which depend for their existence upon the good-will of local societies or communities, to the demands of which they must cater as far as possible. While the latter condition is one that may at the first blush be considered an undesirable handicapping, yet I believe that it has been largely instrumental in bringing about the high usefulness and the esteem in which these stations are held by the agricultural population.

I think, in fact, that not only is this fulfillment of the wishes and the answering of the practical questions of the local agricultural populations a legitimate function, but one of the chief conditions—the *raison d'etre* of their existence in this country at this time. The discussions had in Congress before the enactment of the Hatch bill show clearly that the usefulness of the stations to the population, and not merely the development of agricultural science as such, was the leading argument that carried the bill. It is quite natural, then, that a failure to fulfill the expectations entertained in this respect should lead to unfavorable criticism, which may in the end involve serious danger to the system. That to a great extent such expectations were, and are, unreasonable, and incapable of fulfillment under the circumstances and within the time-limit of the existence of the stations, is quite true; but that fact supplies a major reason for enlisting the interest and the understanding of the farmers most actively in behalf of the station work.

It has been alleged, and somewhat persistently, that such a policy would be unscientific and, as it were, beneath the dignity of the stations. To this allegation I most emphatically demur. We are very far, in this new country, from being in possession of even any considerable portion of all the facts bearing upon the success or failure of agriculture in the several portions of our immense domain. Over a very large portion of this area, the questions that confront the farmer, and therefore the problems that should be solved for him by the experiment stations, are wholly dissimilar from those that form the legitimate subject of investigation

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in the Old World. The farmers' successes and failures are largely due to causes entirely different from those to which corresponding phenomena may reasonably be attributed in the Old World, where centuries of experience have established both general and local rules that have advantageously stood in place of scientific guidance before there was a science of agriculture. The station workers should above all things make themselves acquainted with the difficulties actually encountered by farmers, both by inviting their correspondence, and by personal exploration, so far as means will permit. To do this will alone suffice, in most cases, to disarm criticism, especially if the problems presented are then taken hold of by the stations in good faith and with due deference to the facts as they find them. In my personal experience, I have learned to respect greatly the acumen and good sense with which farmers, as a rule, observe the facts subject to their experience; and while they frequently interpret them wrongly as to cause and effect, yet this need not confuse the (presumably) trained observers at the stations. Nor is it true that the gathering-together of these facts and queries is a merely perfunctory amassing of crude material. It will be found on the contrary a most fruitful source of suggestions for purely scientific investigation heretofore neglected, partly because of want of opportunity, within the Old World scope of observation; and new lights are gradually evolved as the facts arrange themselves in connected and logical order. In this respect, our station men enjoy a great privilege as compared with their European colleagues, if they will only recognize it and make use of it. There is so much new, fresh matter within easy grasp, that there is little occasion or excuse for perfunctory trials of newly-named varieties of vegetables, or for emulating the more recondite theoretical researches which the European stations have both the leisure and the opportunities for conducting successfully.

The stations situated west of the Mississippi have as a rule fallen into the general policy of work indicated above, from stress of circumstances; *i. e.*, in consequence of the imperative demands made upon them by the farming population. Then it has sometimes happened that those trained only in the ideas of Europe and of the Atlantic Coast, not appreciating the limitations imposed upon them by the differences of climate and soil, have mistakenly sought to substitute the practices of the old countries to the more laborious investigation of the new field before them, and missing the mark, they have drawn upon the station the condemnation of "practical men."

Such mistakes can hardly be surprising when we consider the history and conditions of the establishment of the stations; and this is the answer I have made to European workers who animadverted upon the small amount of grain in the vast volume of our station literature: "Suppose that thirty-five or forty stations were to-day established in Germany; do you think you could officer them all with experienced men?" The answer invariably has been, "Assuredly not"; generally with the additional remark that it is hard enough to get well-qualified men for all the stations now existing. If such is the fact in Germany, *we* need not feel humiliated if we have not been able to officer all our new stations with men of broad education and possessing the varied scientific and technical qualification required for this work. I think we may consider that we have done well under these conditions; and no doubt much of the "padding" objected to in our station reports would not have been

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printed but for the legal requirement that bulletins shall be issued at least once every three months. While this provision is in some respects a salutary one, yet in view of the necessarily long duration of valid experiments in agriculture, it almost necessarily results in the publication of a good deal of matter which might as well not have seen the light at all, or until "it should have been better digested."

There is one point that should be most jealously guarded by our stations and all those interested in the progress of agriculture, namely, the occasional attempts at interference in the staff appointments by political or local influences having no relation whatever to the legitimate work before them. Nothing can be more fatal to the success of that work, and nothing but stout and determined resistance to all such interference based upon "pulls," the spoils system, or any other consideration than that of fitness, should meet such attempts on the part of station men.

There can be no doubt, also, that in order to meet the large demand for properly qualified men at our stations, more special but still broad training in that direction is needed on the part of our young men. For since agricultural science involves the application of almost every branch of natural science, from the fundamental physics to the uttermost confines of biology, the mere specialist in physics or in biology is of but very limited usefulness in station work. The very broadness of view required in it, constitutes one of it chief attractions, but also one of its greatest difficulties.

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I.

REPORTS ON GENERAL WORK IN THE AGRICULTURAL LABORATORIES.

ANALYSES OF SOILS, ALKALI AND ALKALI SOILS, WATERS, ROCKS AND MINERALS, FERTILIZERS, GYPSUM, FRUITS AND VEGETABLE PRODUCTS (FOOD MATERIAL, FIGS, ORANGES, LEMONS, PRUNES, APRICOTS, PLUMS, BANANAS, OLIVES, ETC.); DISCUSSION OF THE SAME AND RELATED SUBJECTS.

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RECORD AND DISCUSSIONS OF WORK IN THE GENERAL AGRICULTURAL LABORATORIES.

EXAMINATIONS AND ANALYSES OF SOILS, ALKALI, WATERS, FEEDING STUFFS, FRUITS, AND MISCELLANEOUS SUBSTANCES.

I. ANALYSES OF SOILS.

During the period covered in this report there have been more than 175 samples of soils sent in to this Station from parties throughout the State, for examination either as to need of fertilization, fitness for certain crops, or the presence of some cause productive of injury to trees or crops. In the great majority of cases nothing more than a partial analysis was necessary, and acquaintance with the character and composition as well as climatic conditions of the majority of soils of the State enabled us to give the desired information and to offer suggestions as to the capabilities or treatment of the soil in question.

A few chemical analyses of selected soils were made by M. E. Jaffa for purposes of investigation, and these appear in the following pages.

Mechanical analyses of the soil samples sent to the Columbia World's Fair, in Chicago, were made by R. H. Loughridge, and the results are given below. The general table giving these analyses will be found on pages 60 and 76.

A. SIERRA FOOTHILLS.

No. 1645. *Brownish "bedrock" soil* of Sacramento Valley, from the place of R. C. Kell, west of Yuba City, Sutter County. Taken for the Columbian World's Fair exhibit at Chicago. It is a loam of light brownish tint, varying in thickness from 8 to 12 feet, and usually underlaid by gravel. Natural growth, chiefly herbaceous, with scattered white oaks.

No. 1645. *Brownish "Bedrock" Soil, west of Yuba City, Sutter County.*

Coarse materials above 0.5 mm. diameter	1.4
Fine earth	98.6
	100.0

Chemical Analysis of Fine Earth.

Insoluble matter	50.83	67.34
Soluble silica	16.51	
Potash (K_2O)		.74
Soda (Na_2O)		.24
Lime (CaO)		2.06
Magnesia (MgO)		2.13
Br. ox. of manganese (Mn_3O_4)		.02
Peroxide of iron (Fe_2O_3)		8.68
Alumina (Al_2O_3)		11.27
Phosphoric acid (P_2O_5)		.24
Sulphuric acid (SO_3)		.01
Carbonic acid (CO_2)		-----
Water and organic matter		6.98
Total		99.71
Humus		1.28
Ash		.46
Soluble phosphoric acid		.05
Silica		.32

Mechanical Analysis of Fine Earth.

Colloid clay		15.30
Silt	<0.25 mm. hydraulic value	37.02
	0.25 mm.	6.48
	0.5 mm.	10.09
	1.0 mm.	8.15
	2.0 mm.	8.25
Sand	4.0 mm.	5.54
	8.0 mm.	4.74
	16.0 mm.	2.24
	32.0 mm.	.06
	64.0 mm.	.27
Total		98.14
Hygroscopic moisture (absorbed at 15° C.)		5.27
Water capacity		59.90

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The soil is composed chiefly of clay and finest silt, which give it a high capacity for holding water. In its chemical composition the soil is above the average of the lands of the foothills in richness; especially in phosphoric acid and lime. Its durability is also assured, because of the large amount of clay present, which acts as a storage reservoir for plant food. Its tilling qualities are excellent, as indicated by the large lime, iron, and humus percentages, which with good drainage tend to keep the clay in a flocculated condition.

No. 863. *Red foothill soil*, from ridges south of Grass Valley, Nevada County, at an elevation of 2,500 feet above the sea. It overlies the ancient auriferous gravel deposits to a depth of 6 to 10 feet. The timber growth consists of spruce, cedar, fir, and different kinds of pine, and some black oak. On wetting, the color darkens and the soil becomes slightly plastic. The soil is described in the Report on the Experiment Stations for 1888–89, and the chemical analysis also given. Its mechanical composition is as follows:

No. 863. *Red Soil, Grass Valley, Nevada County.*

Coarse materials above 0.5 mm. in diameter	5.60
Fine earth	94.40
	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		24.73
Silt	<0.25 mm. hydraulic value	21.99
	0.25 mm.	10.31
	0.5 mm.	2.35
	1.0 mm.	5.81
	2.0 mm.	5.77
Sand	4.0 mm.	7.43
	8.0 mm.	10.65
	16.0 mm.	4.44
	32.0 mm.	2.88
	64.0 mm.	.75
		97.21
Hygroscopic moisture (absorbed at 15°)		14.30
Water capacity of soil		53.07
Water capacity of fine earth		53.70

The large amounts of the finest sediment, including the clay, gives to the soil its high moisture and water-capacity percentages. The clay is, according to the chemical analysis, largely composed of aluminic hydrate. for the 36.4 per cent of alumina in the soil would require some 40 of soluble silica to form clay, whereas there is but about 11 per cent, thus leaving fully 20 per cent of alumina in the hydrated state. In its capacity for attracting moisture from the atmosphere this soil stands above all others but one of the State thus far examined, while in the water capacity of its fine earth it stands sixth in the table given elsewhere.

No. 986. *Sandy adobe soil* from University vineyard plot, Cupertino, Santa Clara County. This sample was collected for the Columbian World's Fair. The description and chemical analysis of this soil is given in the Experiment Station Report for 1887. In chemical composition the soil contains large percentages of potash, phosphoric acid, and lime. Its mechanical composition is as follows:

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No. 986. *Sandy adobe soil, Cupertino, Santa Clara County.*

Fine gravel above 0.5 mm. diameter	30.3
Fine earth	69.7
	100.0

Mechanical Analysis of Fine Earth.

Colloid clay		20.54
Silt	<0.25 mm. hydraulic value	23.24
	0.25 mm.	4.40
	0.5 mm.	3.89
	1.0 mm.	3.50
	2.0 mm.	4.29
Sand	4.0 mm.	9.29
	8.0 mm.	5.94
	16.0 mm.	4.26
	32.0 mm.	8.19
	64.0 mm.	9.21
		96.75
Hygroscopic moisture		5.14
Water capacity of fine earth		46.60

The chemical analysis shows that the alumina in the above clay is all combined with silica as a true clay, leaving none of the hydrate which forms so large an element in No. 863. Both hygroscopic moisture and water capacity are far below the latter, though mechanically the two soils are very similar. The results point very conclusively to the fact that while the fine material in a soil does have its influence on the moisture and water capacities, yet the nature of the soluble portion exerts by far the greatest effect. And of the latter, the hydrates of alumina and iron are preëminent. Practically this soil rates as a clay loam.

Additional Soils Sent for Partial Examination.

Name.	Locality.	County.	Sender.
Gravelly soil	Oroville	Butte	R. M. Price.
Red clay soil	Oroville	Butte	R. M. Price.
Soil and subsoil	Colfax	Placer	W. A. J. Edinger.
Calcareous silty soil	Amedee	Lassen	J. N. Leefeld.
Red soil, subsoil, and underclay	4 miles east of Placerville	El Dorado	S. L. Turner.
Red soil, subsoil, underclay	Dolde	Shasta	E. D. Rathbun.
Red loam soils	5 and 12 miles east Marysville	Yuba	T. W. Harney.
Red soil, subsoil	Diamond Springs	El Dorado	J. P. Dunlap.
Deep red soil	Diamond Springs	El Dorado	J. P. Dunlap.
Sediment soil	Jackson	Amador	H. D. Emerson.

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B. GREAT VALLEY.

Alluvial soils of Sacramento River, from peach and cherry orchards of D. D. Gammon, Courtland, Sacramento County. An air-dried portion of each soil was leached and the liquid examined, with the following result:

	Peach Orchard.		Cherry Orchard.	
Per cent of matter soluble in water	.112		.091	
Again soluble in water after evaporation	.046		.028	
Insoluble in water after evaporation	.012		.018	
Organic matter	.054		.045	
Percentage Composition of the Soluble Matter.				
Sodium carbonate	23.64		19.78	
Sodium chloride	5.81	40.62	6.97	30.77
Sodium sulphate	11.17		4.02	
Calcium and magnesium salts		11.16		20.33
Organic matter		48.22		48.90
		100.00		100.00

The alkali in these two soils, while quite "black" from the presence of carbonate of soda, is fortunately not in amounts sufficient to produce any prominent injury to the trees. The use of gypsum on the soil will readily prevent any possible damage. There is a good percentage of phosphoric acid in each soil.

No. 1636. *Reddish soil*, from Manton, Tehama County; sent by M. W. Woodward. It represents a district fifteen miles square, which is being rapidly planted in fruit trees.

No. 1636. *Reddish Soil from Manton, Tehama County.*

Coarse materials >0.5 mm		12.00
Fine earth		88.00
		100.00
Analysis of Fine Earth.		
Insoluble matter	15.67	40.79
Soluble silica	25.12	
Potash (K_2O)		.50
Soda (Na_2O)		.26
Lime (CaO)		.51
Magnesia (MgO)		1.14
Br. ox. of manganese (Mn_3O_4)		.05
Peroxide of iron (Fe_2O_3)		18.20
Alumina (Al_2O_3)		24.10
Phosphoric acid (P_2O_5)		.26
Sulphuric acid (SO_3)		.04
Carbonic acid (CO_2)		
Water and organic matter		13.56
Total		99.71
Humus		2.00
Ash		.61
Soluble phosphoric acid		.09
Silica		.25
Hygroscopic moisture (absorbed at 15° C.)		11.92

This soil is remarkable for its large amount of soluble matter, and especially of soluble silicates (probably 60 per cent). Its phosphoric acid is also unusually high, its potash and lime fair, and its humus large.

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Nos. 1698, 1699. *Reddish soils* from Natoma vineyard, Natoma, Sacramento County; sent by the Natoma Vineyard Company, for analysis. They are from different parts of the tract:

	No. 1698.	No. 1699.
Coarse materials above 0.5 mm. diameter	5.00	19.00
Fine earth	95.00	81.00
	100.00	100.00
Analysis of Fine Earth.		
Insoluble matter	76.30	76.53
Soluble silica	3.13 } 79.43	4.13 } 80.66
Potash (K_2O)	.49	.62
Soda (Na_2O)	.29	.14
Lime (CaO)	1.45	1.55
Magnesia (MgO)	.94	.94
Br. ox. of manganese (Mn_3O_4)	.03	.06
Peroxide of iron (Fe_2O_3)	6.87	8.78
Alumina (Al_2O_3)	6.25	3.21
Phosphoric acid (P_2O_5)	.20	.11
Sulphuric acid (SO_3)	.28	.10
Carbonic acid (CO_2)		
Water and organic matter	3.34	4.81
Total	99.57	100.88
Humus	.89	1.06
Ash	1.73	1.48
Soluble phosphoric acid	.05	.09
Silica	.93	.47
Hygroscopic moisture (absorbed at 15° C.)	7.10	4.78

Both of the above soils are rich in lime, potash, and phosphoric acid; the latter, especially in the soil No. 1698, being above the average in California soils.

No. 1055. *Red sandy loam soil* of Fresno Plains, Sec. 9, T. 14 S., R. 19 E., 9 miles west of Fresno; from M. T. Kearney's "Fruitvale" tract. Taken to a depth of 24 inches. Its description and chemical analysis are found on page 29, Report for 1890. This sample was taken for the World's Fair, and its mechanical analysis resulted as follows:

Coarse materials above 0.5 mm. diameter	9.00
Fine earth	91.00
	100.00
Mechanical Analysis of Fine Earth.	
Colloid clay	11.01
Silt: <0.25 mm. hydraulic value	17.17
Silt: 0.25 mm.	1.70
Silt: 0.5 mm.	6.48
Silt: 1.0 mm.	8.49
Silt: 2.0 mm.	12.69
Sand: 4.0 mm.	18.16
Sand: 8.0 mm.	15.41
Sand: 16.0 mm.	3.35
Sand: 32.0 mm.	5.41
Sand: 64.0 mm.	.21
	100.08
Hygroscopic moisture (absorbed at 15° C.)	3.62
Water capacity of soil	35.40
Water capacity of fine earth	42.20

The soil contains visible white specks of potash feldspar: black and golden mica and quartz. Its color is reddish-brown when moist, and grayish-brown when dry; can be tilled at all times.

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The chemical analysis shows that the 6 per cent of alumina present is probably all combined with the soluble silica to form true clay, and the hygroscopic moisture and water capacity is due chiefly to the fine earth present. The latter is about an average for sandy land.

No. 1678. *Alkali silt soil*, from the Culture Experiment Station, Tulare; this is from a large sample taken for purposes of chemical and physical tests in the solution of the alkali problem.

As received, it formed large chunks or clods, representing the hardpan into which black or carbonated alkali transforms any soil containing sufficient clay to give it cohesion. It is mouse-gray in color.

On wetting the *dry* mass it softens quickly, although while moist in the clod water fails to penetrate it. In leaching out the alkali it is necessary to operate somewhat quickly, as in the course of longer time it settles down into a compact mass almost impervious to water. It was leached prior to the mechanical analysis, which resulted as follows:

No. 1678. *Alkali Silt Soil, Tulare Experiment Station.—Mechanical Analysis of Fine Earth.*

Colloid clay		10.42
Silt	<0.25 mm. hydraulic value	21.75
	0.25 mm.	3.06
	0.5 mm.	2.82
	1.0 mm.	6.49
	2.0 mm.	7.65
Sand	4.0 mm.	10.19
	8.0 mm.	13.54
	16.0 mm.	5.28
	32.0 mm.	10.53
	64.0 mm.	2.06
		93.81
Hygroscopic moisture (absorbed at 15° C.)		6.41

According to this analysis this is a sandy or silty loam, which should till readily at all times, as is actually the case where it is not contaminated with black alkali. But where that alkali is present to any large extent it stubbornly resists the plow so that the pick and crowbar must be used to loosen it.

No. 1466. *Soil* from Miramonte, Kern County, Sec. 17, T. 26 S., R. 23 E.; sent by G. A. Raymond, Rancho Palma. "The sample is taken from the fig orchard, and represents a large streak running from southeast to northwest, and probably covers 200 acres in this section. Everything does well in this soil, even when it is new and without previous cultivation. The growth of trees on it last spring (1890) was immense. On it are fig trees (White Adriatic), now in their third year from the nursery, with trunks 4 to 6 inches in diameter, with corresponding tops. They have made a heavy growth this year, though setting but little fruit. The soil bakes hard when flooded. It is tillable when moist."

No. 1466. *Fig Soil from Miramonte, Kern County.*

Coarse materials >0.5 mm.		1.00
Fine earth		99.00
		100.00

Analysis of Fine Earth.

Insoluble matter	61.93	76.81
Soluble silica	14.88	
Potash (K_2O)		1.04
Soda (Na_2O)		.39
Lime (CaO)		1.39
Magnesia (MgO)		1.24

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Br. ox. of manganese (Mn_3O_4)	.13
Peroxide of iron (Fe_2O_3)	6.27
Alumina (Al_2O_3)	8.29
Phosphoric acid (P_2O_5)	.22
Sulphuric acid (SO_3)	.04
Carbonic acid (CO_2)	.....
Water and organic matter	4.03
Total	99.65
Humus	.60
Ash	.28
Soluble phosphoric acid	.04
Silica	.22
Hygroscopic moisture (absorbed at 15° C.)	4.80

The soil is very rich in all that pertains to plant food except humus, the nitrogen-supplying ingredient, which is, however, in fair supply.

Additional Soils Sent for Partial Examination.

Name.	Locality.	County.	Sender.
Sacramento Valley.			
Tule soil	Dutton's Landing	Solano	J. W. Dutton.
Calcareous loam of Indian mound	Yolo Orchard	Yolo	E. C. Zane.
Sac'to alluvium (2)	Sacramento	Sacramento	C. H. Bentley.
San Joaquin Valley.			
Gray sandy soil	8 miles s.w. of Mendota	Fresno	Philip Douglass.
Soils and subsoils (4)	Sunnyside	Fresno	John Darling.
Sandy soil and subsoil	Fresno	Fresno	Kern County Land Co.
Red sandy soil and subsoil	Fresno	Fresno	A. E. Smith.
Calcareous hardpan	Fresno	Fresno	A. E. Smith.
Sandy loam	Fresno	Fresno	F. J. Laird.
Black alkali soil	Fresno	Fresno	F. J. Laird.
Dark loam	Fresno	Fresno	F. J. Laird.
Dark loams (soil and subsoil)	Oleander	Fresno	R. C. Sloan.
Sandy soil	Fresno	Fresno	Fowler & Smith.
Sandy soil	Fresno	Fresno	J. S. Dore.
Sandy soil	Fresno	Fresno	J. S. Dore.
Soils (3)	Kern City	Kern	Miss S. M. Thompson.
Yellow loam soils (3)	Firebaugh	Fresno	A. C. Vandivier.
Sandy soil and subsoil	White's Bridge	Fresno	P. Dengler.
Soil	O'Neals	Madera	J. H. Oester.
Reddish subsoil	O'Neals	Madera	J. H. Oester.
Alluvial loam soil	Tulare	Tulare	W. C. Imp. Co.
Silty alkali soils (1, 2, and 3 feet)	1 mile south of Pixley	Tulare	E. S. Colburn.
Coarse sandy soils (1, 2, and 3 feet)	1 mile south of Pixley	Tulare	E. S. Colburn.
Dark gray sandy loam	1 mile south of Pixley	Tulare	E. S. Colburn.
Reddish sandy loam	Dinuba	Tulare	A. Sharman.
Light sandy loam	Dinuba	Tulare	A. Sharman.
Chocolate soil	Lerdo	Kern	W. T. Armstrong.
Calcareous hardpan	Lerdo	Kern	W. T. Armstrong.
Soil, subsoil, and clay		Merced	Charles Welch.
Sandy loams (2)	Dos Palos	Merced	E. E. Smith.
Black abode soils (2)	Dos Palos	Merced	E. E. Smith.
Loam soils (4)	Near Dos Palos	Merced	William Hatteroth.
Sandy soil	Farmington	San Joaquin	L. Weitz.

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C. COAST RANGE.

No. 1647. *Redwood soil*, from the land of Colonel J. B. Armstrong, Guerneville, Sonoma County. Collected for the Columbian Exhibition by Colonel Armstrong. The soil has a heavy redwood forest growth and is but little cultivated, though highly productive of grapes and deciduous fruits.

No. 1647. *Redwood Soil, Guerneville, Sonoma County.—Analysis of Fine Earth.*

Chemical Analysis.

Insoluble matter	65.47	75.33
Soluble silica	9.86	
Potash (K_2O)		.99
Soda (Na_2O)		.16
Lime (CaO)		.90
Magnesia (MgO)		1.97
Br. ox. of manganese (Mn_3O_4)		.03
Peroxide of iron (Fe_2O_3)		5.77
Alumina (Al_2O_3)		7.69
Phosphoric acid (P_2O_5)		.16
Sulphuric acid (SO_3)		.02
Carbonic acid (CO_2)		.....
Water and organic matter		6.50
Total		99.52
Humus		.62
Ash		.27
Soluble phosphoric acid		.06
Silica		.10

Mechanical Analysis.

Colloid clay			16.54
Silt	<.25	mm. hydraulic value	16.86
	.25	mm.	3.57
	.5	mm.	3.44
	1.0	mm.	4.09
	2.0	mm.	7.21
Sand	4.0	mm.	9.82
	8.0	mm.	13.35
	16.0	mm.	7.98
	32.0	mm.	9.84
	64.0	mm.	5.75
			96.90
Hygroscopic moisture (absorbed at 15° C.)			5.14
Water capacity			52.30

This is a first-class soil, and highly productive when planted in grapes and deciduous fruits. Its percentage of potash is very high, its phosphoric acid good, and its lime fair. There is less humus than might be expected from a forest soil. Its water capacity is remarkably high.

Soils of Alexander Valley, 5 miles east of Healdsburg, Sonoma County; sent by Alex J. Young, San Francisco.

No. 1. "Soil of bottom land from flats bordering the creek. Depth of soil unknown, but not less than 10 feet. Water is found in wells dug on this land, at a depth of 25 feet during summer months. The land is well protected from winds, except from the south. The temperature in summer is often high, with occasional fogs; in winter it is subject to somewhat severe frosts."

The soil is a loam, dark from organic matter, which, when burnt off, leaves the soil reddish in color, similar to that of the hills. It is gravelly, but with water is plastic. The percentage of phosphoric acid is very low.

No. 2. "Dark red soil taken from an elevated plateau about 125 feet above the creek. The land is at present uncleared, and is covered with a heavy growth of manzanita, madrone, white and black oaks, and fir trees. The situation is somewhat exposed, but less subject to frosts than the bottom lands. The depth of the soil is unknown, but at four feet the soil is identical with that of the surface."

The soil is rather stiff, its lumps not yielding very readily to water. The percentage of phosphoric acid is low.

No. 1655. *Red vineyard soil* of Napa Valley, from the vineyard of H. W. Crabb, 3 miles east of Oakville and 1 mile from hills, Napa County. Vegetation originally white or "foothill" oaks. The soil is a reddish-gray loam, containing considerable angular gravel.

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The following shows the chemical composition of the soil taken to a depth of 10 inches:

No. 1655. *Crabb's Red Vineyard Soil, Oakville, Napa County.*

Coarse materials >0.5 mm.	24.85
Fine earth	75.15
	100.00

Chemical Analysis of Fine Earth.

Insoluble matter	64.33	73.03
Soluble silica	8.70	
Potash (K_2O)		1.28
Soda (Na_2O)		.26
Lime (CaO)		.54
Magnesia (MgO)		.91
Br. ox. of manganese (Mn_3O_4)		.03
Peroxide of iron (Fe_2O_3)		7.70
Alumina (Al_2O_3)		8.79
Phosphoric acid (P_2O_5)		.09
Sulphuric acid (SO_3)		.01
Carbonic acid (CO_2)		
Water and organic matter		7.11
Total		99.75
Humus		1.05
Ash		.66
Soluble phosphoric acid		.04
Silica		.36

Mechanical Analysis.

Colloid clay		21.73
Silt	<.25 mm. hydraulic value	31.64
	.25 mm.	5.10
	.5 mm.	4.96
	1.0 mm.	5.47
	2.0 mm.	6.22
Sand	4.0 mm.	4.63
	8.0 mm.	2.94
	16.0 mm.	3.36
	32.0 mm.	4.12
	64.0 mm.	6.56
		96.72
Hygroscopic moisture (absorbed at 15° C.)		4.25
Water capacity		47.40

The above analysis marks the soil as very high in potash and medium in lime and phosphoric acid, indicating a probable need of the latter in a few years. It is composed very largely of clay and finest silt, which give a high power for holding water, but it is very low in hygroscopic moisture.

No. 1679. *Black adobe soil*, from the University grounds, Berkeley, Alameda County. The sample was taken for the Columbian World's Fair, to the depth of 3 feet, and a large quantity was also well mixed and stored for special investigations. The chemical and mechanical analyses of the samples so obtained resulted as follows:

No. 1679. *Adobe Soil from University Grounds, Berkeley.*

Coarse materials above 0.5 mm. in diameter	15.00
Fine earth	85.00
	100.00

Analysis of Fine Earth.

Insoluble matter	54.50	73.50
Soluble silica	19.00	
Potash (K_2O)		.73
Soda (Na_2O)		.20
Lime (CaO)		1.15
Magnesia (MgO)		1.08
Br. ox. of manganese (Mn_3O_4)		.04
Peroxide of iron (Fe_2O_3)		8.43
Alumina (Al_2O_3)		7.92
Phosphoric acid (P_2O_5)		.19
Sulphuric acid (SO_3)		.04
Carbonic acid (CO_2)		
Water and organic matter		6.54
Total		99.82
Humus		1.21
Ash		.94
Soluble phosphoric acid		.04
Soluble silica		.69

Mechanical Analysis of Fine Earth.

Colloid clay		44.27
Silt	<.25 mm. hydraulic value	22.70
	.25 mm.	2.65
	.5 mm.	3.57
	1.0 mm.	4.48
	2.0 mm.	5.42
Sand	4.0 mm.	6.72
	8.0 mm.	3.97
	16.0 mm.	1.33
	32.0 mm.	.92
	64.0 mm.	.43
		95.46
Hygroscopic moisture (absorbed at 15° C.)		11.98
Water capacity		50.40

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On comparing the above with previous analyses of adobe soils from near the same locality taken to one foot depth only, we find one third more clay, while the amount of fine silt is almost the same in all. There are also differences in the amounts of coarser materials.

The percentages of potash and lime are much greater in this sample, while that of phosphoric acid is about an average of the analyses previously made. The humus content is materially much less (about one half) in this 3-foot sample than in the surface soil of 12 inches depth formerly analyzed.

Soils, subsoils, etc., from Soquel Valley, Santa Cruz County; sent by Mrs. M. N. Clark and Marston Niles of Santa Cruz. The valley lies along Soquel Creek, which flows southward into Monterey Bay.

"The ranch from which the soils were taken is three miles from the bay. Here the valley is one third of a mile wide, and on each side is bounded by hills about 200 feet high. The slope on the east, near which the creek flows, is very steep and well timbered with oak and redwood; the hills on the west are much less abrupt, and chiefly pasture lands, and only in the gulches have redwood growth. This side (on which the ranch is located) slopes gently to the creek, in places falling off suddenly into successive low terraces. The valley continues southward for about two miles toward the bay, when the side-hills sink down and the valley presents a plateau of about 80 feet in height, thence to the bay. To the northward the valley continues some miles with about the same width, and then the land rises into what is known as 'Highland' and 'Skyland' of the Santa Cruz Mountains."

Five samples of soil, with their respective subsoils, underclays, etc., to depths of several feet, in all about thirty specimens, were taken and sent as representative of the tract. Two typical soils are presented in this collection—a grayish sandy soil of the lower portion of the valley, and a black "redwood soil" of the higher, at an elevation of about 50 feet above the creek. The soils are deep, and no change occurs in tint at a less depth than 12 inches, and in some cases several feet. Both soils are poor in phosphoric acid, and require of course the application of superphosphates or bone-meal, for full productiveness.

No. 1693. *Dark soil*, from Paso Robles, San Luis Obispo County; sent by Van R. Elliott. The samples are from the first bench west of the Salinas River, in the town of Paso Robles. The soil is 12 or 14 feet deep, underlaid by 5 feet of sand and 4 inches of cemented, round bowlders. The analysis was made by Marvin Curtis, laboratory assistant.

No. 1693. *Soil from Paso Robles, San Luis Obispo County.*

Coarse materials >0.5 mm.	55.00
Fine earth	45.00
	100.00

Analysis of Fine Earth.

Insoluble matter	74.58	86.30
Soluble silica	11.72	
Potash (K_2O)		.51
Soda (Na_2O)		.05
Lime (CaO)		1.04
Magnesia (MgO)		.34
Br. ox. of manganese (Mn_3O_4)		.01
Peroxide of iron (Fe_2O_3)		3.06
Alumina (Al_2O_3)		3.20
Phosphoric acid (P_2O_5)		.29

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Sulphuric acid (SO_3)	.06
Carbonic acid (CO_2)	.....
Water and organic matter	4.92
Total	99.81
Humus	1.85
Ash	1.18
Soluble phosphoric acid	.025
Silica	.90
Hygroscopic moisture (absorbed at 15° C.)	7.60

The soil is thus shown to be fairly supplied with potash and rich in phosphoric acid, with a fair amount of lime. Its hygroscopic power is high for so sandy a soil, and is probably due to the large amount of soluble silicates.

Soils from Cholame Valley and table land 22 miles northeast of San Miguel, Sec. 14, T. 23 S., R. 14 E.; sent by C. Salomonson, of Berkeley.

"The valley lies between San Joaquin Valley on the east and San Miguel. The atmosphere is clear and without fogs. The temperature does not exceed 108.7° in summer; while in the winter months there are some years when in January or February water contained in vessels freezes. Snow very seldom falls in the valley, while of rain there is usually an average of 16 inches. Prunes grow well in the valley soil, producing fruit of first quality. On this soil oak trees also grow very rank. On the table land bordering the valley, at an elevation of 50 feet above it, there is a growth of chaparral, pine, and oak, the latter two becoming large and firm."

The specimen of *valley soil* taken to 12 inches below the surface is a dark loam, which, kneaded with water, becomes slightly plastic. It contains a fair amount of lime and phosphoric acid. With good depth and proper irrigation the soil should produce abundantly both fruits and grain.

The samples of soil from the adjoining table lands comprise three varieties: a light calcareous loam, with a fair amount of phosphates but with little humus; a reddish-brown clay, not calcareous but stiff and tenacious, not easily crushed between the fingers when dry, though yielding readily to water, and containing a fair amount of lime and phosphates; and a dark calcareous clayey loam, quite tenacious when wet, and containing more phosphates than the other samples.

The following description of the Cholame Valley is from Mr. J. V. Webster, former Patron of the Experiment Station at Paso Robles: "That portion of the valley above the mouth of Cholame River and on either side of the San Juan Creek varies from one half to a mile in width between the hills, which are more rugged and precipitous than on the Estrella Plains. The soil varies greatly and much of it is dry and gravelly, very little being adapted to safe or successful cultivation. There is no timber save a few scrub-oak and some willow along the creek. The soil is not as good as the average of the Estrella or Carisa Plains."

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Additional Soils Sent for Partial Examination.

Soil.	Locality.	County.	Sender.
Soil	Bridgeville	Humboldt	E. C. Mason.
Yellow loam soil, subsoil	Eureka	Humboldt	Fruitland Ra'ch.
Dark "prairie" loams (2)	Happy Valley	Humboldt	M. R. Jager.
White pasture soil		Lake	A. Beverly.
Red hill soil			
Dark chocolate valley soil.	Dry Creek Valley, near Healdsburg	Sonoma	C. W. Keys
Dark loam hillside soil			
Red clay subsoil			
Hillside soil and subsoil			
Soil and subsoil	Los Guilicos	Sonoma	S. A. Karns.
Soil and subsoil			Ed. Anderson.
Dark loam soil	Alexander Valley	Sonoma	Alex. J. Young.
Deep red plateau soil			
Red gravelly clay soil and subsoil	Glen Ellen	Sonoma	Mrs. O. Gordenker.
Stiff foothill clay soil and subsoil			
Stiff clay soil and subsoil			
Red mountain soil[a]	Napa	Napa	E. P. Blagrove.
Red mountain subsoil[b]			
Clay soil, subsoil	Rancho del Valle	Alameda	A. G. Platt.
Clay soil			
Clay adobe			
Black adobe	San Leandro	Alameda	E. Musson.
Dark red hill soil			
Black adobe		Santa Clara	Mrs. E. N. Fuller.
Dark adobe soil[c]	Evergreen	Santa Clara	W. H. Robinson.
Light soil[d]			
Soil[e]	Watsonville	Santa Cruz	C. H. Rogers.
Dark clay soil, subsoil	Campbell Station	Santa Clara	E. C. Armstrong.
Soil[f]	Near San José	Santa Clara	Geo. Goodacre.
Subsoil[g]			
Adobe soils (3)	San José	Santa Clara	E. Geisel.
Red loam soil	Los Gatos	Santa Clara	B. L. Bartlett.
Gravelly clay subsoil			
Reddish loam soil			
Red clay subsoil			
Dark loam soil and subsoil			
Dark sandy hillside loam	Cayucos	S. Luis Obispo	Rev. S. Slocombe.
Light sandy soil			
Soil	Paso Robles	S. Luis Obispo	V. R. Elliot.
Soil	Santa Barbara	Santa Barbara	P. Rice.
Soil	Carpenteria	Santa Barbara	C. Lillingston.
Dark loam soil	Santa Barbara	Santa Barbara	J. J. Perkins.
Soils and subsoils (7)	Piru Ranch	Ventura	Leslie F. Gay.
Light sandy loams (5)	Santa Maria	Santa Barbara	T. N. Warner.

[a]The red mountain soil contains .106 per cent of lime and .112 per cent of phosphoric acid.
[b]The subsoil contains .154 per cent of lime and .123 per cent of phosphoric acid.
[c]The dark adobe soil contains .70 per cent of lime and .43 per cent of phosphoric acid.
[d]The light soil contains .52 per cent of lime and .27 per cent of phosphoric acid.
[e]The soil contains .18 per cent of phosphoric acid.
[f]The soil contains .99 per cent of lime and .05 per cent of phosphoric acid.
[g]The sub-soil contains 1.93 per cent of lime and .15 per cent of phosphoric acid.

D. SOUTH CALIFORNIA.

No. 1284. *"Adobe" soil* from the moist lands bordering Chino Creek. South California Experiment Station, near Pomona. A mouse-colored, moderately heavy loam, somewhat silty; the dry lumps crush quite readily between the fingers, and show little or no grit. With acid there is effervescence because of the presence of carbonate of lime; on wetting, the color deepens considerably, and when kneaded the soil

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becomes quite adhesive, showing that it must not be tilled while wet. The chemical analysis is given on page 38 of the Report for 1890, and shows large potash, phosphoric acid, and lime percentages; the alumina is probably all in combination as true clay. The following is the mechanical analysis of this soil:

No. 1284. *"Moist Adobe" Soil, Experiment Station, near Pomona.*

Coarse materials above 0.6 mm. in diameter	10.00
Fine earth	90.00
	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		13.44
Silt	<0.25 mm. hydraulic value	20.65
	0.25 mm.	1.37
	0.5 mm.	4.91
	1.0 mm.	5.95
	2.0 mm.	13.46
Sand	4.0 mm.	10.36
	8.0 mm.	9.25
	16.0 mm.	12.01
	32.0 mm.	2.75
	64.0 mm.	1.66
		95.81
Hygroscopic moisture (absorbed at 15° C.)		5.98
Water capacity		60.20

In this soil we have somewhat of an anomaly in a rather low power for absorbing moisture in a saturated atmosphere at a low temperature, and a high capacity for holding water. That the former may be due to the absence of aluminic hydrate (the alumina being in the form of clay, as shown in the chemical analysis) can be readily supposed; but why the water capacity should be so high with but 44 per cent of clay and fine silt is not clear.

No. 1663. *Red mesa soil*, from the home place of A. J. Twogood, in the center of the town of Riverside, and from the first orange orchard planted in that region. It represents a medium between the heavy and light orange lands. The specimen was taken by J. C. Cutter.

No. 1663. *Red Mesa Soil, Riverside.*

Coarse materials above 0.5 mm. diameter	4.00
Fine earth	96.00
Total	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		19.37
Silt	<0.25 mm. hydraulic value	12.20
	0.25 mm.	5.63
	0.5 mm.	4.22
	1.0 mm.	12.19
	2.0 mm.	18.52
Sand	4.0 mm.	17.90
	8.0 mm.	6.92
	16.0 mm.	.52
	32.0 mm.	.11
	64.0 mm.	.12
		97.70
Hygroscopic moisture		5.06
Water capacity		53.20

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This soil is rich in clay and silt, while its sand is of the finest grades, thus giving to it a high capacity for holding water. Its hygroscopic power is, on the contrary, quite low.

No. 1281. *Reddish-gray sandy loam* of the South California Experiment Station, near Pomona. The soil when wet darkens a little and becomes slightly plastic, but not adhesive. The soil is described in the Experiment Station Report for 1890–91, and its chemical analysis given. Its main chemical features are high percentages of potash, phosphoric acid, and lime, thus indicating high fertility under proper physical conditions.

The following is the result of the mechanical analysis:

No. 1281. *Reddish Mesa Soil, South California Experiment Station.*

Coarse materials above 0.5 mm. in diameter	10.00
Fine earth	90.00
	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		7.80
Silt	<0.25 mm. hydraulic value	15.82
	0.25 mm.	3.61
	0.5 mm.	5.49
	1.0 mm.	3.92
	2.0 mm.	6.40
Sand	4.0 mm.	7.92
	8.0 mm.	11.57
	16.0 mm.	18.36
	32.0 mm.	14.65
	64.0 mm.	5.20
		99.24
Hygroscopic moisture (absorbed at 15° C.)		1.98
Water capacity of fine earth		49.96

The soil is low in both hygroscopic power and water capacity, when we compare it to soils that reach 14 of the former and 60 to 80 of the latter. For so sandy a soil it, however, has fair percentages of both of these. Its chemical analysis indicates that all of its alumina is in the form of true clay, otherwise the moisture and water coefficients would probably be higher.

Soil from Redlands, San Bernardino County; taken from the Lugonia ridge, a low elevation in the northern part of the town; sent by John W. Pears. It is fawn-colored, coarsely sandy, granitic in character.

"The soil is apparently the same in character for the three feet represented by soil and subsoil; and the same has been observed at a depth of 10 or 15 feet below the surface. The soils of the Lugonia region vary considerably in character, some being much lighter and sandier than others. To the southward they become heavier, until at about a mile from where the samples were taken they pass into the red lands of the valley. This sandy soil absorbs a great deal of water, and more water has to be used than on the red lands. Manure put on it, unless thoroughly rotted and pulverized, will lie for a long time unchanged."

The above soil is very sandy in nature and contains scarcely any clay, which accounts for the rapid leaching complained of. It is evidently from one of the cienega debris ridges described by Professor Hilgard in an article on "The Cienegas of Southern California" in this report.

Soils from tract of the Manzana Colony, situated on the northern slope of the La Lieber range of mountains, west end of Antelope Valley, Los Angeles County; sent by T. W. Haskins.

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The elevation is about 2,700 feet above the sea. The rainfall is 10 or 12 inches per year, and the mean temperature in winter, from 18° to 24°. The climate is too cold for citrus fruits, but supposed to be adapted to apples, pears, almonds, peaches, apricots, figs, cherries, etc. Water is found at a depth of 120 to 150 feet below the surface in the valley, and at bedrock on slopes of the mountain. The soils are all granitic in origin, and hold much quartz gravel and sand, and golden mica. A small ridge of granitic debris lies at the mouth of a cañon, and on this the soil has but little clay and is very deficient in potash, though there is a small amount of lime. On either side of this ridge the soil is darker

Of late years the propriety of preparing the soil extract for general analysis by digestion in beakers covered with a watch glass, as mostly practiced heretofore, has been called in question; chiefly on the ground that under such conditions the chlorhydric acid employed might vary in strength in consequence of evaporation. It has therefore been proposed to carry out the digestion in closed flasks under what is supposed to be rigorously uniform conditions, and within a shorter time.

While too much importance cannot be attached to uniformity of

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methods in soil analysis, there is a limit beyond which it is idle to attempt to go, as regards the strength of acid employed in digestion. For unless we were to vary the amount or strength of the original acid in accordance with the greater or less amount of soluble matter in the soil (ranging all the way from 40 per cent and even more, to 7 per cent only), the strength of the acid *must* vary not inconsiderably during digestion, unless either an indefinitely large quantity of the same were employed, or a preliminary determination were made for each soil before proceeding to the actual preparation of the soil solution. Either expedient is liable to serious objections; it therefore becomes a matter of importance to determine, directly, the extent of the variations to which the acid is liable under the evaporation actually occurring in beaker digestion.

Leaving aside for the moment the question of the proper strength of acid to be employed in preparing the soil solution, it should be remembered that, as Kolb has elaborately shown, chlorhydric acids of constant strength are obtained by free evaporation under the continued influence of any given temperature and pressure.

BEHAVIOR OF CHLORHYDRIC ACID UNDER EVAPORATION.

The fact that chlorhydric acid of nearly constant strength (sp. g. 1.11 per cent, or 23.5 per cent HCl) is readily obtained by the distillation of stronger acid, originally led Dr. D. D. Owen to use such acid in his work on soils; and I continued his practice on the strength of his verbal statement that such acid would on the steam bath remain sensibly (so far as needed in this case) of constant strength.

In view of the objections now made I have thought it best to once more subject the matter to experimental test, the results of which are given in the table below. Fifty ccm. of chlorhydric acid of 1.116 sp. g., obtained by the distillation of the last two thirds of stronger acid under atmospheric pressure, was evaporated on the steam bath to one half its bulk; the same diluted with 10 per cent of water was similarly treated. Furthermore, the same experiment was made with two procelain beakers ("soil pots") covered with watch glasses, being kept on the steam bath for five days, as usually practiced by us in soil digestion. In the latter two cases, the bulk had been reduced to 36 ccm., or by somewhat over one fourth of the original volume.

	Strength of Acid. Per cent Anhydrous HCl.		
	Desk Acid Composition per cent HCl.	Desk Acid Evaporated to ½ its bulk.	Desk Acid Evaporated to 5 cc.
Desk acid in open beaker	22.96	21.49	20.96
Desk acid with 10 per cent water	20.67	21.49	----------
Desk acid in covered porcelain beaker	22.96	21.49	----------
Desk acid with 10 per cent water, in covered porcelain beaker	20.67	21.49	----------

It will thus be seen that under the ordinary conditions of digestion as heretofore practiced in this laboratory, the changes arising from evaporation are absolutely insignificant in comparison with those unavoid-

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ably resulting from the variable amount of soluble matters in different soils. There remains, therefore, no rational foundation for the contention that digestion in close flasks offers any advantage over porcelain beaker digestion under watch glass. On the contrary, the chance of increased pressure in a close flask exerting a disturbing influence, together with the greater solubility of the best glass as compared with porcelain, and the greater complexity and liability to accident of the whole arrangement, should tell heavily against its adoption in preference to the other method. Contrary to Kedzie's contention, I am unable to observe any change whatever in the smooth, shining surface of Berlin porcelain beakers that have been in use for fully twelve years.

Kedzie claims as an advantage the shorter time required for digestion in his closed flask. To this I emphatically demur, for the reason that if the action is so much more energetic it is so much the more liable to serious variations of results, in consequence of accidental variations in time of digestion. The plant action which we are trying to imitate is very slow. In Loughridge's experiments, made in 1873, it was found that there was practically no difference in the result obtained, whether the digestion by our method was continued for five or for ten days. If this is generally true (a point now under investigation), it constitutes a distinct advantage, in proving that we have here reached an approximation to a maximum of solvent action, such as will not be easily exceeded by plants within the time in which we are interested. Since that is precisely what we should aim at, I am at a loss to perceive the advantage of the exacerbation of solvent action proposed by Kedzie, Snyder, and others. It should certainly first be shown that there is something to be gained by it, *i. e.*, that the results so obtained are better capable of intelligent interpretation in correspondence with cultural experience.

COMPARISON OF THE ACTION OF HYDROCHLORIC AND OXALIC ACIDS IN SOIL EXTRACTION.

By M. E. Jaffa.

This investigation was undertaken with a view of ascertaining the solvent action of oxalic acid on soils as compared with that of hydrochloric acid. For this purpose two soils were selected, one the *black adobe* from the University grounds, and the other a *reddish, sandy soil* from near Lancaster, Antelope Valley, Los Angeles County, as representing two distinct types.

The hydrochloric acid used was of 1.1150 specific gravity, containing about 23.5 per cent anhydrous acid, and the oxalic acid solution was made of corresponding strength.

The digestion was conducted in porcelain beakers, and continued in the usual way for five days, at the end of which time the analysis was, for the hydrochloric acid solution, made in the prescribed manner. In the case of oxalic treatment, the solution was immediately filtered from the insoluble residue; the filtrate evaporated to dryness in a platinum basin, ignited to expel the excess of oxalic acid, and the resulting residue dissolved in hydrochloric acid and treated as usual.

One phosphoric acid determination answers for both analyses, and,

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with the humus and nitrogen contents, is merely inserted to complete the analyses.

Below in tabular form are given the results obtained:

Comparative Analyses of Soils by Hydrochloric and Oxalic Acids.

	No. 1679. Black Adobe Soil, University Grounds.		No. 1607. Reddish, Sandy Soil, Antelope Valley, Los Angeles County.	
	With Hydrochloric Acid.	With Oxalic Acid.	With Hydrochloric Acid.	With Oxalic Acid.
Coarse materials >0.5 mm.	15.00	15.00	30.00	30.00
Fine earth	85.00	85.00	70.00	70.00
Analysis of Fine Earth.				
Insoluble matter	54.50	59.81	80.48	87.25
Soluble silica	19.00 } 73.50	15.37 } 75.18	6.77 }	89.34
Potash (K_2O)	.73	.73	.49	.47
Soda (Na_2O)	.20	.18	.15	.11
Lime (CaO)	1.15	.62	.97	.41
Magnesia (MgO)	1.08	1.04	.93	.85
Br. ox. of manganese (Mn_3O_4)	.04	.03	.05	.04
Peroxide of iron (Fe_2O_3)	8.43	8.26	4.23	3.86
Alumina (Al_2O_3)	7.92	7.29	4.19	3.42
Phosphoric acid (P_2O_5)	.19	.19	.07	.07
Sulphuric acid (SO_3)	.04	.04	.04	.04
Carbonic acid (CO_2)				
Water and organic matter	6.54	6.54	1.40	1.40
Total	99.82	100.10	99.77	100.01
Humus	1.21		.25	
Humus ash	.94		.20	
Containing phosphoric acid	.04		.01	
Containing silica	.69		.13	
Humus nitrogen in 100 humus	18.58		16.80	
Humus nitrogen in 100 fine earth	.203		.042	
Hygroscopic moisture (absorbed at 15° C.)	11.98		1.22	

An inspection of the data here presented shows that, on the whole, hydrochloric acid exerts a stronger influence in the soil than does oxalic acid; as in both sets of analyses it is noticed that the insoluble residue is, in the case of the hydrochloric acid digestion, about 2 per cent higher than is that resulting from the action of oxalic acid.

The amount of *potash* (0.73 for the adobe and 0.47 for the sandy soil) dissolved is identical in the two treatments, while the quantity of *lime* extracted by hydrochloric acid is about twice that yielded by the oxalic acid, as is indicated by the figures 1.15 and 0.62 for the adobe soil, and 0.97 and 0.41 for the sandy. As regards *magnesia* there is very little difference.

The percentages of *iron* and *alumina* are both lower when oxalic acid is used as the solvent. The water and organic matter percentage is the same, as it was determined only in that portion of the soil used for the phosphoric acid determination.

In summing up, we might say that, except in the case of lime, the results obtained by the action of oxalic acid on soils could receive the same interpretation as that given to those derived from the hydrochloric acid treatment.

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It is our intention to digest these two soils with citric acid solution of a strength corresponding to the hydrochloric acid used, and publish the resulting data as soon as possible.

ANALYSIS OF TWO KENTUCKY BLUE GRASS SOILS.

By M. E. Jaffa, for the Association of Official Agricultural Chemists.

The two soils are from near Lexington, Kentucky, and were sent for analysis by Prof. A. M. Peter, of the Kentucky Experiment Station and Reporter on the Methods of Soil Analysis for the Association:

	Soil No. 2.		Soil No. 3.	
Analysis of Fine Earth.				
Insoluble matter	69.02	78.09	73.88	82.24
Soluble silica	9.07		8.36	
Potash (K_2O)		.71		.48
Soda (Na_2O)		.16		.10
Lime (CaO)		.46		.41
Magnesia (MgO)		.41		.32
Br. ox. of manganese (Mn_3O_4)		.05		.04
Peroxide of iron (Fe_2O_3)		5.47		5.04
Alumina (Al_2O_3)		6.58		5.24
Phosphoric acid (P_2O_5)		.71		.40
Sulphuric acid (SO_3)		.04		.06
Carbonic acid (CO_2)				
Water and organic matter		7.23		5.69
Totals		99.91		100.02
Humus		2.43		1.83
Humus ash		2.42		2.17
Containing phosphoric acid		.19		.17
Containing silica		1.22		.98
Hygroscopic moisture (absorbed at 15° C.)		8.62		6.51

The results as shown by the above analyses fully confirm the great productiveness of the Blue Grass region of Kentucky.

The most striking feature of these soils is the very high percentage of phosphoric acid found in them; both the total amount, and that readily soluble portion contained in the humus ash. The figure 0.71, obtained for soil No. 2, was so surprisingly high that a re-determination was rapidly made, giving a result agreeing so closely with the first determination as to leave no doubt of its correctness. No soil that we have examined, so far, shows such a richness in this important element of plant food. The nearest approach in natural soils is in the black waxy prairie soils of Texas (Vol. 6, Tenth U. S. Census), where 0.59 per cent has been obtained; where reported, and in the soils derived from the basaltic formation of central Montana, which have yielded as high as 0.36 per cent phosphoric acid.

The average of this constituent for the humid region of the United States, as derived from the analyses of 466 soils, is .117 per cent, which is less than about one sixth and one third, respectively, the amounts found in soils Nos. 2 and 3. A greater difference is shown when these per cents are compared with 0.083, the average of over two hundred California soils. While the total percentages (0.71 and 0.40) of phos-

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phoric acid are so high, those found in the humus ash are also exceedingly large, being 0.19 and 0.17, respectively, which are more than twice the *total* quantity usually contained in the California soils.

These soils being located in a calcareous formation their lime contents are somewhat high, but still are less than one half that found as the average for the California soils, viz., 1.08.

As to potash, while the average of 466 soils of the humid region of the United States is only 0.218, yet such percentages as are here shown are not uncommon in the lowland soils of even the East. No. 2, with its 0.71 per cent, has little more than the average, 0.65, for California, and No. 3 only about four fifths of this amount.

Both these soils are more than adequately supplied with humus, as is indicated by the figures 2.43 and 1.83, respectively.

ON THE NITROGEN CONTENTS OF SOIL HUMUS IN THE ARID AND HUMID REGIONS.

By E. W. Hilgard and M. E. Jaffa.

The "organic" nitrogen of soils has usually been determined by combustion of the organic matter in the whole soil, deducting in some cases that which was known to exist in the nitrate form, from a separate determination.

The combustion method is in any case very inaccurate, so far as it is intended to give the amount of humus nitrogen in the soil. For it necessarily includes the entire organic matter, which varies greatly with the season, and which may or may not ultimately become wholly or partially humified. In order to attain results related definitely to the content of actual functional humus, the latter must be extracted from the soil mass by some solvent which discriminates between the different forms of "organic nitrogen," viz., the humified and the unhumified.

That this cannot be done by direct extraction with fixed caustic alkalies, which inevitably not only dissolve unhumified matters, but also tend to expel ammonia from the amidic compounds, is manifest. Their well-known direct action in humifying the cellulose group of compounds add to the gravity of the objection to their use.

The only method thus far known which distinctly excludes the unhumified matters while eliminating the whole of the properly humified portions, is that of Grandeau: the extraction of the soil first with dilute acid, in order to set the humic substances free from their insoluble combinations with lime and magnesia, and their subsequent extraction with moderately dilute solutions of ammonic or other alkaline hydrates. Notwithstanding the objections raised against this method by Huston and McBride, and its admitted inaccuracy in the case of acid soils, when ammonia is employed for extraction (ammonia from the solvent being then chemically fixed and added to the weight of the humus), its results afford the only clew we have to the true amount of active humus substances in soils. The variations resulting from any moderate variations in the strength of the solvent or in time of digestion, are insignificant in comparison with the utter incommensurableness of the results obtained by any other method.

While we have many desultory determinations of nitrogen in soils

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and peats in which the "humus" was determined by lye-extraction or combustion, there are very few of the "*matiére noire*" itself, even Grandeau having failed to come to any definite conclusion regarding its normal nitrogen contents; which, according to his verbal statement to me, has varied, in his own experience, from 3 to 6 per cent and over. In my investigation of soils from the humid region (Mississippi and Louisiana especially) I have usually assumed 4 to 5 per cent as the average.

In view of the extremely small percentages of organic matters, and particularly of the true humus, in the upland soils of the arid region (rarely up to 0.5 and frequently less than 0.2 per cent), I had supposed that a lack of nitrogen might often be the cause of unthriftiness; and in such cases I have repeatedly recommended the use of nitrogenous fertilizers. To my surprise, in several cases such applications proved ineffectual and even injurious, proving plainly that the soil was not nitrogen-hungry. The suggestion that if the small amount of humus suffices in the case of arid soils to satisfy the demand for nitrogen, that humus must be richer in nitrogen than usual, was obvious; and it is the purpose of this paper to communicate, summarily, the results thus far obtained in investigating this problem, by a comparison of the nitrogen content of the *matiére noire* from arid soils, with that from soils of the humid region.

In discussing the question it must be kept in mind that while arid conditions can rarely be fulfilled in the humid region, humid conditions may frequently occur in the arid. The extreme of arid conditions will be found in the uplands and desert plateaus; while in the lowlands, moisture frequently remains within reach of the surface even during the dry season, so that the actual conditions may be semi-arid or locally even humid. Even in the uplands, the bottoms and lower slopes of ravines will be less arid than the higher slopes. Again, it might be expected that close, heavy soils having a high moisture-coefficient may differ measurably in their behavior from the characteristic soils of the arid region (viz., the loose, pervious sandy or "dust" soils), in which eremacausis can progress so freely during the dry season that the surface not uncommonly shows a lower humus percentage than the subsoil. Again, as we ascend a range of mountains the rainfall increases; so that at a certain elevation humid conditions will have replaced the aridity of the valleys or plateaus.

It is therefore not to be expected that all soils from localities west of the 100th meridian should show the characteristics of arid soils; and all degrees of transition between the two extremes are to be looked for. It is also to be expected that when land is irrigated during the dry season, the original characteristics will gradually be modified in conformity with the new régime.

The subjoined table exhibits the results thus far obtained in the investigation of this question. The soils have been arranged in accordance with their known natural occurrence, and include both soils of the extreme arid and humid types, as well as such as within the limits of the arid region must, from their location, be considered as being within the semi-arid or humid region. Thus the soils of plateaus or "mesas" within the arid region must be considered strictly within the arid category; while those of valleys and river bottoms within the same region, being kept in a more moist condition by the greater proximity of bottom water, must be accounted semi-arid only. The soil of marshes, "tule

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lands," and swamps is of course within the humid régime, wherever situated. In the hill lands it may easily happen that one and the same soil is strictly under arid conditions on the ridges, while in the ravines and hollows, and in "springy" places, it exists under humid conditions. Hence it is necessary, in conducting such investigations, to work with samples of perfectly known origin.

SOILS FROM ARID REGION.

		Humus Per Cent in Soil	Nitrogen Per Cent in Humus	Nitrogen Per Cent in Soil
	Uplands, California.			
1113	Slate soil (c. l.) Exp. Sta., near Jackson, Amador Co.	.54	16.60	.090
1115	Granite soil (sd.) Exp. Sta., near Jackson, Amador Co.	.85	13.20	.112
1291	Manzanita soil (sd.) McKay Tract, Jackson, Amador Co.	.76	14.34	.109
1117	Granite soil (pine) (sd.) Fleming Tract, Jackson, Amador Co.	.80	15.27	.123
863	Red ridge soil (l.) near Grass Valley, Nevada Co.	2.89	13.91	.402
	Blk. adobe soil (c.) University Grounds, Berkeley, Alameda Co.	1.20	18.58	.203
1147	Loam soil (sd.) front land, Exp. Sta., S. L. Obispo Co.	.66	16.06	.106
1126	Loam soil (sd.) rear land, Exp. Sta., S. L. Obispo Co.	.55	17.27	.095
1423	Chocolate colored soil (l.) Carisa Pl'n., S. L. Obispo Co.	.39	14.36	.056
704	Fresno Plains (sd.) Central Colony, Fresno Co.	.60	18.66	.112
1159	Plains soil (sd.) Exp. Sta., Tulare Co.	.37	16.75	.062
1172	Red lands soil (c. l.) 12 miles east of Tulare, Tulare Co.	.72	14.75	.106
1167	Black lands soil (c. l.) 3 miles west of Tulare, Tulare Co.	1.66	18.19	.302
332	Plateau soil (l.) near Mojave Station, Kern Co.	.28	12.50	.035
1607	Plateau soil (sd.) nr. Lancaster (Mojave Pl'n.), L. Angeles Co.	.25	16.80	.042
1406	Red soil (sd. l.) Arlington Heights, Riverside Co.	.30	15.00	.045
1536	Brownish soil (l.) Windsor Tract, Arlington Heights	.20	18.00	.036
1281	Reddish mesa soil (sd.) Exp. Sta., nr. Chino, Los Angeles Co.	.58	15.50	.090
	Average of uplands	.75	15.87	.101
	Lowlands, California.			
1148	Swale soil (sd.) Exp. Sta. Tract, S. L. Obispo Co.	1.16	9.65	.112
77	Alluvial soil (l.) S.E. cor. Tulare Lake, 1878, Tulare Co.	.47	9.37	.045
585	"Wire grass" soil (l.) near Visalia, Tulare Co.	1.00	14.10	.148
586	Tulare Plains soil (sd.) east of Outside Creek	1.14	10.79	.123
1466	Loam soil (sd.) Miramonte, Kern Co.	.60	10.66	.064
168	Santa Clara River alluvium (st.), Santa Paula, Ventura Co.	.84	7.99	.067
1284	Adobe or moist soil (c.) Exp. Sta, nr. Chino, S. Bernardino Co.	1.99	10.20	.203
506	Colorado River alluvium (st.) near Yuma, San Diego Co.	.75	7.47	.056
	Average of lowlands	.99	10.03	.102

HUMID SOILS FROM ARID AND HUMID REGIONS.

	California.			
207	Eel River alluvium (st.) east of Ferndale, Humboldt County	1.25	6.96	.087
188	Red mountain soil (sd. l.) near Sonoma, Sonoma County	2.54	4.53	.115
110	Putah Valley alluvium (c. l.) Dixon, Solano County	1.71	4.25	.072
213	Marsh soil (sd. l.) Novato Meadows, Marin County	1.54	6.36	.098
37	Redwood valley soil (l.) Pescadero, San Mateo County	2.28	3.07	.070
	Other States.			
	Bog soil, Michigan, No. 26	*33.02	6.08	*2.013
	Back-lands soil (c. l.) near Houma, Louisiana, No. 240	5.07	4.30	.218
	Prairie soil (sd.) Pierce's Junction, Harris County, Texas	2.13	8.66	.184
	Red soil (l.) (old soil) Kohala Plantation, Kauai, H. I.	7.80	2.93	.229
	Average	3.04	5.24	.132

*Introduced only for comparison of the nitrogen percentage in humus; omitted from averages.

NOTE.—c. stands for clay; l. for loam; sd. for sand; st. for silt.

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A mere glance at the figures of this table suffices to show the great and rather surprising differences existing between the nitrogen contents in the arid and humid soils. Whatever may be the minor faults or uncertainties of the method employed, the fact that it was applied to all with perfect uniformity, can leave no question as to the general result.

It thus appears that on the average, the humus of the arid soils contains three times as much nitrogen as that of the humid; that in the extreme cases, the difference goes as high as over six to one (see Nos. 37 and 704); and that in the latter cases, the nitrogen percentage in the arid humus actually exceeds that of the albuminoid group, the flesh-forming substances.

It thus becomes intelligible that in the arid region a humus percentage which under humid conditions would justly be considered entirely inadequate for the success of normal crops, may nevertheless suffice even for the more exacting crops. This is most clearly seen on inspection of the figures in the third column, which represent the product resulting from the multiplication of the humus percentage of the soil into the nitrogen percentage of its humus; as appears in comparing the respective averages, or Nos. 1167 and 110 and others.

We must not, then, be misled by the smallness of humus percentages in the arid region, into the assumption of a deficiency in the supply of soil nitrogen.

It is moreover not at all improbable that in the case of a humus substance so extraordinarily rich in nitrogen, the nitrifying process may assume a special impulse, particularly under the concomitant favoring conditions of temperature, porosity, and the invariable presence of earthy carbonates. As is well known, it is precisely in the arid regions that the nitrate deposits that have assumed such capital importance in modern agriculture, have been formed. The same fact is apparent in the numerous analyses of alkali salts in which the presence of notable amounts of nitrates in arid soils is shown. (See reports of the California Experiment Station.) In this connection the soil No. 1159 of the table is of special interest. It is a strongly alkaline soil, containing in its salts a large proportion of carbonate of soda, together with considerable amounts of the nitrate and phosphate of the same base, and potassic sulphate. In leaching this soil a filtrate is obtained of almost inky-black color from dissolved humus. Yet this humus when precipitated is found to contain nearly 17 per cent of nitrogen. It would thus seem that under the conditions existing in this soil the alkali carbonate does *not* prevent the accumulation of nitrogen in the humus substance; yet, at the same time it is often abundantly evident, even to the olfactory sense, that under the influence of a hot sun there is a decided tendency to the disengagement of free or carbonated ammonia. Under such conditions nitrification must be greatly favored, provided the nitric ferment is not prevented from exerting its action by an injurious excess of the alkaline carbonate. In the latter case it is still possible for the plants capable of resisting the corrosive action of the alkali to absorb the nitrogen needed in the form of ammonia directly. But in the view of the known energetic action of gypsum in favoring nitrification, the remarkable effects of plaster on lands afflicted with "black alkali" receive additional explanation.

It is but natural to suppose that the physical and chemical nature of

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the soil may materially affect the accumulation of nitrogen in the soil humus, outside of climatic influences. A detailed discussion of the table does not indicate that in general, as might have been expected, the accumulation is greater in porous soils than in compact ones; the reverse seems to hold good. It is also indicated that the presence of a large proportion of earthy carbonates tends to favor the accumulation of nitrogen; which would be in entire accord with the observations of Armsby, Wollny, and others, regarding the favoring of oxidation (formation of CO_2) by lime or its carbonate when in contact with organic substances. On the other hand, the presence of a large proportion of finely divided ferric hydrate seems to tend in the opposite direction. contrary to what, according to our knowledge of that substance under apparently similar conditions, would have been expected. I have repeatedly noted, both in the arid and humid regions, that the common impression that strongly ferruginous soils are usually poor in humus, is a delusion due to the obscuration of the dark humus tint by the rust color of the ferric hydrate.

There is one general point that is pregnantly illustrated by this investigation, viz., the marked difference in the mode and results of the decomposition of animal matter on the one hand, and of vegetable on the other. In the former case we have, first of all, a copious evolution of ammonia compounds and their analogues; and under natural conditions at least the residues of the process, if any, are mostly poor in nitrogen. In the case of vegetable matter, under similar conditions, the carb-hydrate portion of the mass is first attacked, and the residue becomes richer in nitrogen, until finally it accumulates to the extent of a higher percentage than in the albuminoids themselves. It is not altogether easy to formulate a general explanation of these facts; but they are certainly of great practical as well as theoretical interest.

INVESTIGATIONS IN SOIL PHYSICS.

By R. H. Loughridge.

[In view of the many significant facts brought out in the course of soil investigation during twenty-four years past, it is thought best to put on record in the following pages a summary presentation of observations thus far made by us, in order that future experimenters may have the benefit of the same. The complexity of the subject is so great that perfectly definite conclusions cannot be reached without the concurrent investigation of a vast number of natural soils under varied conditions, from varied materials, and the concurrent discussion of the results from both the chemical and physical point of view.—E. W. H.]

THE MECHANICAL COMPOSITION OF SOILS WITH REFERENCE TO MOISTURE AND WATER MOVEMENTS.

The analysis of soils with reference to their mechanical constituents has been in progress at this Station at intervals for fifteen years, and the results are here combined in one table, in order to draw as far as possible some conclusions, either positive or negative, as to the relation of the various sediments or ingredients to the power possessed by soils to absorb hygroscopic moisture, to their capacity for holding water, and to their power of transmitting water by capillarity.

These analyses have all been made by means of the soil elutriator

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Number of Soil	
2	
11	
11	
16	
8	
10	
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16	
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16	
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1	
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* Landw. Versuchstationen, 35, 1888, p. 69 *et seq.*
† Proceedings of the Am. Ass'n for the Advancement of Science, Portland meeting, 1873, page 83.

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quently happens that a very large proportion of the alumina found has neither silica nor any other acidic oxide to combine with. It is manifestly present, in part, in one or several other forms, among which in some cases the hydrate (*e. g.* gibbsite) seems to be the only imaginable one. I have formerly found a number of such cases in the soils of Mississippi; they are even more common in a certain class of California soils, notably in those from the great valley and the lower foothills.

It may be claimed that even the pulverulent kaolinite particles excluded from the clay determination made by the twenty-four hours' subsidence, will, in the soil, in the course of time, become macerated and ground into colloidal clay. Probably *all* the conditions contributing to the conversion of pulverulent kaolinite into plastic clay are not yet understood. Johnson has shown that protracted trituration will render floury kaolin sensibly plastic, and the effect of the boiling and kneading ("tempering") of natural clays is well understood in practice. In the latter cases, however, the effect is doubtless largely due to the dissolution of preëxisting flocculent aggregates, rather than to the further reduction of crystalloid kaolinite to the colloidal condition. The very slight trituration that can occur even in the best cultivated lands by the ordinary work of tillage can produce no sensible effect in the latter direction. It has never been claimed that cultivation increases the closeness or plasticity of soils; and hence for the present and practically permanent nature of any soil the *actual* contents of colloidal clay must be considered the measure, to be ascertained by analysis.

It must be remembered, then, that in the following discussion the term "clay" represents the sediment remaining in suspension after twenty-four hours' subsidence, and comprises the extremely fine kaolinite particles, the silicic hydrate, the acid-soluble hydrated silicates or zeolites, the ferric hydrate, aluminic hydrate, and humic hydrates; each of these has doubtless an attraction for water or moisture peculiar to itself, and its presence in the clay, in greater or less proportion, modifies the hygroscopic, water-holding, and capillary powers of the latter, and therefore of the soil. That the "clay" contains nearly all of the zeolites and other mineral salts soluble in hydrochloric acid, was indicated by a series of analyses of the several soil ingredients, obtained from a Mississippi soil, already mentioned in the above paper by Professor Hilgard as having been made by us. It is therefore not only an important physical constituent of all soils, but the chief repository for plant food.

Sources of Water Supply for Plants.—During seasons of drought plants are dependent upon three natural sources of moisture supply in the soil, for preservation of vitality and for growth, viz.: hygroscopic moisture in the surface soil absorbed from the atmosphere; a greater amount of moisture accumulated from rains and held in the soil; and the still greater accumulation of ground-water at depths of many feet from the surface; and by condensation of aqueous vapor in consequence of temperature changes. This latter cause is for the present discussion left out of consideration.

The supply from the ground-water is transmitted to the plant roots by capillary movement between the soil particles, and if the conditions are favorable for such easy movement, and the source not too far below the limit of capillarity, it is entirely sufficient for the growth of the plant. Thus far our experiments show that the best of our soils have the power of raising moisture by capillary movement to a height of less than five feet, while in sandy soils the limit is far less. Should the roots of trees or plants fail to penetrate to within reach of this supply, then they must rely upon the amount of water that the soil is capable of holding from the winter rains (or from condensation by change of temperature). This amount is dependent upon the mechanical and chemical composition of the soil, and is the chief source of supply, especially for deep-rooted crops. When, however, the roots of shallow-rooted crops

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fail to reach this storage supply, they are dependent either upon artificial irrigation or that moisture absorbed from the atmosphere known as *hygroscopic moisture*. The amount of the latter is very meager, but in good soils of fair tilth, there is enough to sustain vitality and in many cases to promote growth.

In the following discussion of these sources of water-supply it is proposed not to take our entire series of chemical analyses of soils, comprising several hundred moisture determinations, but only those in which both the chemical and mechanical constituents have been ascertained; and thus if possible to reach some conclusion as to the influence of these several constituents upon the absorptive power of soils.

INFLUENCE OF SOIL COMPOSITION UPON HYGROSCOPIC MOISTURE.

It is a well-known fact that all solid particles condense upon their surfaces a thin film of moisture from the atmosphere, and that the thickness of this film is dependent upon the degree of moisture in the atmosphere and upon the temperature; that the drier the air the less will be the amount of moisture upon solids. It goes without saying, therefore, that the greater the surface thus exposed to the air within a given volume the greater will be the percentage of moisture in an accumulation of small solid particles such as we find in soils.

There is, however, another factor, and a very strong one, that influences the absorption of moisture by soils, and that is the chemico-physical character of the particles and constituents. Among these may be specially mentioned the humus compounds and the hydrated silicates or zeolites, as well as ferric hydrate, and to a certain extent aluminic hydrate and colloidal clay. All but the latter may be regarded as the soluble constituents of a soil; not soluble in water, but in weak acids, and representing the portion available for the use of plants.

Absorptive Power of the Several Mechanical Soil Ingredients.—A few experiments have been made with the finer of the sediments (obtained in the mechanical analysis) to ascertain their power of absorbing moisture from a saturated atmosphere, and at a constant temperature of about 15° C. Except in the matter of securing large amounts of each, there was no trouble with the sediments, and they were used as obtained from the elutriator. But for the clay, a portion had to be specially prepared by evaporating the clay water and its suspended clay to dryness; for as ordinarily treated for weighing, it is thrown down from suspension by a solution of salt, which is then eliminated by the use of chloride of ammonium. The presence of the latter has its effect on the absorptive power of the clay, as was shown by the experiments.

The following are the results obtained from a sample of the black lands soil near Tulare (No. 1167), the red soil from Grass Valley, Nevada County (No. 863), and the black adobe soil from the University grounds, Berkeley (No. 1679), and the sandy soil of Castroville (No. 1595):

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Hygroscopic Moisture Absorbed by Clays and Silts.

No.	Soils.	Entire Soil.	Clay.	Silts.			
				<0.25.	0.25.	0.5.	1.0.
1167	Black lands soil, Tulare	5.34	17.60	7.96	2.91	1.73	
1167	Black lands soil, with salt	5.34	15.56				
863	Red soil, Grass Valley, with salt	14.20	13.24	12.06			
1679	Black adobe, Berkeley	11.98	22.25	6.05			
1595	Sandy soil, Castroville	1.15					0.31

The amount of moisture absorbed by the several clays in the above table differs very greatly; it is highest in the black adobe and least in the red ferruginous soil of Grass Valley. In any case the amount is greater than in the silts.

It has already been remarked that the clays may be regarded as of complex character, combining not only grains of extremely fine division, but also colloid material, such as ferric, aluminic, silicic, and humic hydrates, and that these exist in the soils in greatly varying proportions. Thus in the black adobe with the highest moisture percentage there is 40 per cent of these hydrates; in the black lands of Tulare 21 per cent, and in the Grass Valley red clay there is as much as 62 per cent. In the first two, however, there is more of the silicic and aluminic hydrates than in the latter, and these have a stronger attraction for moisture than the ferric hydrate which forms the greater part of the clay from Grass Valley. It thus seems more than probable that the large percentage of moisture absorbed by the adobe clay is substantially due to the excess of the true colloidal clay above that contained in either of the other soils.

The negative effect of some salts, such as ammonic chloride, is shown in the above table; the Grass Valley soil, entire, has a moisture coefficient of 14.2, almost the maximum of the list of forty-two soils, yet lower than its clay alone in which ammonic chloride was present. The black lands soil with the salt absorbed 15.5 per cent, but with most of the chloride driven off it absorbed 17.6 per cent. The amount absorbed by the entire soil was only 5.38 per cent.

The presence of this ammonic chloride salt in most of the above clays prevents at present a discussion with regard to the chemical nature of the soluble compounds held by each. In the general discussion of the soils themselves with reference to hygroscopic moisture and water-capacity they will again be mentioned.

The materials coarser than clay in the above list have in all cases a lower moisture coefficient: the finest silts varying in amount because of the presence of some soluble silicates. The coarser the grains comprising the group the smaller is the percentage of moisture, until in the sands alone we find less than 1 per cent.

The following table, comprising those soils of which both mechanical and chemical analyses have been made, is arranged in the order of high to low percentages of hygroscopic moisture for each division of soils into clays, clay loams, loams, sandy loams, and sandy soils. The other columns show the percentages of clay, and of clay combined with the several series of silts and fine sands, which gives to each column an additional amount of coarser material to that presented in the preceding

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column. We can thus compare the relative percentages of moisture with the amount of various sediments in each soil, and also, in a measure, the effect produced by the combinations. In the last columns showing chemical composition, the soluble silicates, embracing all the matters soluble in hydrochloric acid, except lime carbonate and iron oxide, occupy one column, while the total of soluble matter fills the third column.

A glance over the several columns shows that there is no uniform or nearly uniform gradation in the percentages of material running parallel with the moisture figures from highest to lowest; that the soil having the highest moisture is not characterized by the highest clay or the highest combination of clay and silts which comprise the finest ingredients, and are supposed to offer the greatest surface to the deposit of moisture.

We may say, though, that as a very general rule those soils having the largest amount of finest ingredients belong to the class of highest moisture coefficients, and that *vice versa* the coarse sandy soils are very low in moisture; but it is not an exact rule, for even in those soils embraced in the table there are many striking exceptions, and for which the cause must be sought, not in mechanical composition alone but in the chemical, and even then other causes seem in some cases to have a controlling influence.

The general question at present is, what is it in the soil that causes the greater absorption of moisture, the clays singly or when combined with the fine silts, with their large surface area; or is the amount of suluble chemical compounds of greater influence than these?

Perhaps the most feasible method of making comparisons between the several ingredients as a whole, is that of ascertaining the number of points or movements the figures in each column would make if rearranged in the order of highest to lowest, each figure being moved upward. A comparison of the several totals would show at a glance the column most in accord with the column of moisture percentages. As a matter of course, the fewer there are of such movements the more nearly will such a column be in accord with that of the hygroscopic moisture, and will indicate a stronger influence upon the absorption of such moisture.

A number of the soils have not been analyzed chemically, and, for purposes of comparison, we will omit them from the list; we thus find the following as the number of points through which the figures in each column will have to be moved for adjustment from highest to lowest:

Mechanical Ingredients.

Clay alone	147 points.
Clay combined with the two lowest silts	148 points.
Clay with silts to .5 mm. hydraulic value, inclusive	156 points.
Clay with silts to 1 mm. hydraulic value, inclusive	160 points.
Clay with silts to 2 mm. hydraulic value, inclusive	165 points.

Chemical Ingredients.

Total soluble compounds	136 points.
Soluble silicates alone	120 points.

The result strongly indicates that the soluble silicates or zeolitic compounds have a stronger influence upon moisture absorption than the mere surface area of the particles alone. These silicates doubtless represent largely the colloidal portion of the "clays," and their low percentage in soils with high clays doubtless affords the reason why in the table some of the latter stand below soils with lower clay percentages.

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MECHANICAL ANALYSES OF SOILS ARRANGED IN THE ORDER OF HYGROSCOPIC MOISTURE.

No.	Name and Character.	Locality.	Hygroscopic Moisture.	Mechanical Analysis.					Chemical Analysis.			
				Clay.	Clay to .25 mm.	Clay to .5 mm.	Clay to 1 mm.	Clay to 2 mm.	Soluble Silicates.	Total Soluble Material.	Ferric Hydrate.	Humus.
	CLAY SOILS.											
6	Black adobe	Stockton	14.53	32.63	74.0	79.5	85.1	87.1	22.3	29.1	7.7	----
863	Red soil	Grass Valley	14.20	24.78	57.1	59.5	65.3	71.0	54.0	62.3	9.5	2.9
188	Red mountain soil	Sonoma	13.70	52.24	67.9	71.8	77.9	82.4	26.9	52.9	29.7	2.5
643	Black waxy soil	Colton Ranch	13.51	43.54	79.1	81.7	84.8	87.5	28.4	39.5	12.7	1.5
1679	Adobe soil	University	11.98	44.27	69.6	73.2	77.7	83.1	----	----	----	----
68	Adobe	Chinese Camp	11.19	26.10	62.5	65.5	70.3	76.3	34.2	43.2	----	1.6
676	Red volcanic soil	Clear Lake	11.11	29.84	61.2	64.9	71.0	77.0	34.3	44.8	12.0	1.4
77	Dry bog soil	Tulare Lake	10.38	29.79	45.2	47.4	55.6	64.2	18.0	34.0	5.8	.5
110	Alluvial soil	Putah Creek	10.32	31.49	76.8	80.4	85.4	89.8	20.7	28.7	9.1	1.7
789	Upland adobe soil	Mission San José	9.74	34.16	54.0	56.6	58.1	61.7	15.0	18.8	4.4	.7
506	Bottom soil	Colorado River	9.26	23.97	55.8	67.1	79.7	88.1	16.4	37.0	4.7	.8
8	Non-alkali soil	Stockton	9.18	20.80	56.1	62.7	68.3	75.6	----	----	----	----
1	Black adobe soil	University	7.52	31.93	57.7	61.1	65.9	73.4	16.7	21.4	5.4	----
2	Black adobe subsoil	University	5.14	33.53	61.7	67.6	74.6	81.0	24.1	31.3	8.3	----
986	Sandy adobe soil	Cupertino	5.10	20.54	48.2	52.1	55.6	59.9	13.2	19.9	7.7	1.0
1655	Red vineyard soil	Crabbs, Oakville	4.20	21.73	58.5	63.0	68.5	75.7	19.1	26.8	8.8	1.1
9	Alkali soil	Stockton	2.63	26.10	54.0	63.5	69.7	75.9	----	----	----	----
	CLAY LOAMS.											
67	Mining slum soil	Chinese Camp	10.26	18.47	46.7	54.9	65.5	77.5	18.1	27.4	10.5	0.4
1113	Red foothill soil	Experiment Station	6.00	16.43	51.3	61.3	69.0	77.2	23.8	35.3	13.7	.5
168	Valley silt soil	Santa Paula	5.49	15.02	30.2	35.3	43.3	56.0	8.6	11.9	3.9	.8
1645	Alluvial soil	Yuba City	5.27	15.30	58.8	68.9	77.1	85.4	23.7	32.4	10.0	1.3
4	Adobe ridge soil	University	5.18	18.92	41.0	47.8	57.2	63.8	11.0	15.0	4.6	----
1647	Redwood soil	Guerneville	5.14	16.54	37.0	40.4	44.5	51.7	18.4	24.2	6.8	.6
1663	Red mesa soil	Riverside	5.06	19.37	37.2	41.4	53.6	72.1	----	----	----	----
	LOAMS.											
10	Sediment soil	Sacramento	9.18	12.06	55.6	68.7	82.4	92.7	25.1	31.4	7.3	----
1678	Sandy alkali soil	Tulare	6.41	10.42	45.3	48.1	54.6	62.3	----	----	----	----
1115	Granitic soil	Amador	5.93	11.86	32.8	36.1	40.0	45.9	21.0	26.3	6.2	.5
1284	Moist-land soil	So. Cal. Exp. Station	5.81	13.44	35.5	40.4	46.4	59.9	13.6	28.8	7.3	2.0

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1167	Black lands soil	Tulare	5.38	14.65	38.9	44.4	47 9	54.9	16.2	21.2	5.8	1.3
586	Plains soil	Outside Creek	4.86	10.48	34.9	37.1	47.7	53.9	16.5	22.2	6.6	1.1
1055	Red sandy loam	Fresno	3.62	11.01	29.9	36.4	44.9	57.6	13.4	20.9	8.5	.4
51	Red foothill soil	Auburn	3.17	13.91	45.8	51.4	62.8	78.8	18.2	31.6	13.4	1.1
130	Reddish loam	San Gabriel	2.30	10.70	27.3	33.9	39.0	46.1	13.1	19.4	7.3	.....
	SANDY LOAMS.											
1159	Sandy plains soil	Tulare	4.00	5.71	16.7	20.8	26.3	33.4	13.7	20.6	7.6	.4
47	Red mesa soil	National Ranch	2.30	9.66	21.0	24 2	28.0	33.9	9.6	13.3	4.4	.6
1281	Mesa soil	Chino Ranch	1.98	7.60	26.1	31.6	35 5	41.9	13.4	22.5	8.2	.6
1147	Sandy loam soil	Paso Robles	1.84	7.40	25.2	31.2	39.8	48.2	5.8	9.6	4.3	.7
	SANDY SOILS.											
1197	Gila bottom soil	Gila River	3.48	3.21	8.7	10.7	13.9	24.1	8.9	23.1	7.4	.....
1148	Swale soil	Paso Robles	3.43	3.09	24.6	27.8	38.1	45.9	6.7	10.0	3.8	1.2
1595	Sandy soil	Castroville	1.15	2.60	8.9	9.2	12.7	13.6	.....	.....	.....	.....
233	Sandy soil	Morano	.79	2.82	5.2	6.0	6.5	8.7	.....	.....	.....	.....

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THE EFFECT OF THE DIFFERENT INGREDIENTS UPON MOISTURE ABSORPTION.

"*Clay.*"—A glance at the column of "clay" percentages in the soils shows immediately that there is no very close correspondence or ratio between the clay and amount of moisture absorbed by the soil. The combined surface area of the particles of clay in a clayey soil is very great, and in the loose condition in which they were exposed to an atmosphere saturated with moisture at a temperature of 15° C. we would naturally anticipate a correspondingly large condensation of moisture, and that the highest percentage of clay would bring with it the highest percentage of moisture for that soil; but such proves not to be the case, for the red mountain soil with its 52 per cent of ferruginous clay absorbed but 13.7 per cent of moisture, while the black adobe with but 32.6 of clay absorbed 14.5 per cent; and an adobe ridge soil with 33.5 of clay could be made to take but 5.1 of moisture. Again, we find that an alkali soil with 26.1 of clay stands near the foot of the column of moisture percentages with only 2.6 per cent. And thus all down the column, we constantly find high "clays" with comparatively low moistures and just above each a low clay with higher moisture.

In the following table are arranged sixteen of the soils with highest clays in their natural order, in order to show more clearly this variation, and the rank of each with reference to moisture:

No.	Soil.	Clay Percentage.	Moisture Percentage.
188	Red mountain soil	52.24	13.70
1679	Adobe soil	44.27	11.96
643	Black waxy soil	43.54	13.51
789	Upland adobe	34.16	9.74
2	Black adobe soil	33.53	5.14
6	Black adobe soil	32.63	14.53
1	Black adobe soil	31.93	7.52
110	Alluvial soil	31.49	10.32
676	Red volcanic soil	29.84	11.11
77	Dry bog soil	29.79	10.38
68	Adobe soil	26.10	11.19
9	Alkali soil	26.10	2.63
863	Red soil	24.78	14.20
506	Bottom soil	23.97	9.36
1655	Red vineyard soil	21.73	4.20
986	Sandy adobe soil	20.54	5.10

The high percentage of "clay" of the red mountain soil is due largely to the iron oxide that it contains (26 per cent for the whole soil, a part of which, however, passed over into the next silt class), so that it should properly give its place to the adobes which naturally have very large clay percentages, and all with two or three exceptions stand at the head of the moisture list.

Among the silt analyses of Mississippi soils and subsoils, given in the paper of Professor Hilgard, read before the American Association for the Advancement of Science, in 1873, we find an analysis of a white pipe-clay; its composition is:

Clay	74.65
Finest silt	21.15
Fine silt	2.00
Coarser material	0.36

The clay in this may be regarded for the most part as kaolinite, or true clay, without the presence of much of the zeolitic mineral which

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forms an important constituent of the clay of soils. Its moisture coefficient was found to be 9.09, or a little more than one half of that of the soil clays reported on a previous page.

In the same table we find that the Flatwoods soil of Pontotoc County with only 25 per cent of clay has almost the same moisture coefficient (9.33), and that a red hills soil of Attala County absorbs 18 per cent of moisture, or twice that of the pure clay. This red hill soil has about 25 per cent of ferric hydrate, and to this may be credited the high absorptive power.

Again, in the marsh soils of West Pascagoula, Mississippi, as reported in the Geology of that State, we find a predominance of coarse material and very little clay, but a large percentage of organic matter. The clay thus plays but an insignificant part, yet we find the moisture percentage to be 15.00, clearly due to the organic matter.

The conclusion is apparent that the "clays" do not in themselves control the amount of hygroscopic moisture that is absorbed by soils, although they do largely influence it.

If we were to rearrange the present column of clay percentages of the forty-one soils presented in the table, by moving them up until they read from highest to lowest, there would be a total of 211 movements.

Clay and Silts.—If we add to the clays the two lowest of the silt groups in the elutriator series, we find that the black waxy soil of Contra Costa County (No. 643) is highest, and the alluvial soil No. 110 second, in combined weight; the black adobe No. 6 which has the highest moisture coefficient is brought to the third place instead of the sixth, when its clay alone is considered, thus indicating that so far as itself is concerned, the combined fine material is more hygroscopic than its clay.

If to this combination of clay and silt we add the percentages of other silts, the parallelism between each column and that of the hygroscopic moisture is not improved, but on the contrary the irregularity becomes greater, thus showing that the three finest of the ingredients has the greater absorptive power. In the rearrangement of the figures in each column, as in the case of the clay, we find a gradual increase in the number of points passed for each column, and from 211 and 198 in the two first columns of clay, and "clay and finest silts," respectively, we have at the last 221 for the clay and total percentages of silts.

In this connection it may be well to briefly refer to a remarkable group of soils from the Sandwich Islands, specimens of which have been recently received and are being examined. They are very highly ferruginous and very rich in mineral matter soluble in hydrochloric acid, more than 50 per cent being thus soluble. The moisture coefficient is extremely high in all of the soils examined, ranging from 16.0 to 37.4 per cent; and in each may be attributed to some special ingredient. Thus, the soil with 37 of moisture has the highest humus, 10.9, with high percentages of hydrated silicates and ferric hydrate. The soil with 29 per cent of moisture has very little of hydrated silicates, but a very large amount of the hydrate of alumina; its humus is 7.2. Another soil, with 21.7 of moisture, has very little humus, but about 18 per cent of free hydrated silica. Mechanical analyses have not been made of these soils, but as far as we can judge from their character, they have practically the same amount of clay and fine material, and if their moisture coefficient were dependent alone upon this, there should be little difference in their percentages.

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CHEMICAL COMPOSITION WITH REFERENCE TO MOISTURE ABSORPTION.

We are not prepared now to undertake to consider the relation of each of the chemical compounds within the soil to the hygroscopic coefficient, for the state of combination of these elements is a matter of some uncertainty; we can only take as a whole the total of substances soluble in hydrochloric acid and the isolated group of soluble silicates (including the hydrated silicates of alumina, potash, soda, lime, etc., hydrated silica, and aluminic hydrates). The ferric hydrate and lime carbonate are included in the soluble material. There are only three in the list of soils given in the table that contain a very large amount of aluminic hydrate, viz.: the red soil No. 863 from Grass Valley, with 25 per cent; the red volcanic soil of Lake County, with 17 per cent, and the alluvial soil of Putah Creek, Yolo County, with its 9.2 per cent.

In glancing over the columns of total soluble substances and of soluble silicates as arranged in the table, there is seen to be the same irregularity as noted in that of the mechanical ingredients, though not to so great an extent. There is also this notable difference, that, with the exception of the black adobe (which has the highest moisture percentage and only 29 per cent of soluble matter), the five soils having highest total soluble matter, and also highest soluble silicates, stand highest in hygroscopic moisture. This cannot be said of the "clays." It is notable also that in the rearrangement of the figures to read from highest to lowest the number of points to be passed is less than in rearrangement of the columns of mechanical ingredients.

These results appear to clearly indicate that the influence of the chemical constituents of a soil toward moisture absorption is greater than of a mere mechanical subdivision as represented by "clays" and silts.

From the above it will be seen that there is required a great deal more of direct investigation of soils *in their natural condition* to elucidate this important subject. Artificial mixtures in which kaolin is made to represent the "clay" (as has been done by some European investigators), cannot give results applicable to natural soils.

CAPACITY OF SOILS FOR HOLDING WATER.

The power of a soil to hold within itself a supply of liquid water derived either from rains, interior condensation of moisture, or from underground sources, is of great importance; for upon this supply is dependent the moisture and the solution of necessary nutritive mineral matters to promote the vitality and growth of the plants. The conditions most favorable for such storage of moisture (though not for the growth of plants) are not alone the combined surface area of the soil particles as in the absorption of hygroscopic moisture of the air, but in the amount of space between the particles in bulk; provided the adjacent particles are not so far apart as to prevent the entire space being filled with the water by natural capillary attraction. In coarse, sandy soils, for instance, the interspaces are so great that percolation and drainage rapidly take place, a portion of each space is left vacant, and the soil is found to be low in water-capacity. On the other hand, in clayey soils the interspaces are

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so extremely minute as to be entirely filled with water. In loams which combine both clay, silt, and sand, the two former fill, to some extent, the spaces between the grains of sand, and thus increase the retentive power.

It must always be remembered, however, that the chemico-physical character of the soil particles, and other conditions surrounding them, have a great deal to do with their relations to water; in some instances fine soils ("dust soils") have been found which in a dry condition refuse to take water (each drop of which rolls up into a little ball, the surface of which is covered with a thin film of the soil), and which, even after long contact, fail to permit free absorption or percolation.

A prominent case in point is thus mentioned by Professor Hilgard as observed by him in the State of Washington a few years ago:

"The difficulty of making soils take irrigation water is a matter of common note and complaint in the alluvial plains bordering the Yakima River, particularly in the northern division known as the Atahnam prairie. When first taken into cultivation the soil is so difficult to penetrate with moisture that to reach 12 inches sidewise from the ditch sometimes requires as many hours. In the upper part of the plain mentioned, along the Nachees, small irrigating ditches have to be run three feet apart, at most, in order to obtain a uniform stand of grain; when farther apart the grain in the middles would dry up as though unirrigated.

"The same has been noted at other points in this State and Oregon and Washington, where such 'dust soils' prevail. These soils have the following mechanical composition:

Dust Soils of Washington and Oregon.

Mechanical Composition.	17 Atahnam Prairie, Yakima Co., Wash.	87 Rattlesnake Creek, Kittitas Co., Wash.	79 Plateau on Willow Creek, Morrow Co., Oregon.
Colloid clay	.93	3.59	1.27
Silt (of <.25 millimeters hydr. value)	30.93	13.06	32.29
Silt (of .25 to .5 millimeters)	3.20	5.82	12.75
Silt (of .5 to 2.0 millimeters)	7.18	27.37	37.51
Sand (of 2.0 to 8.0 millimeters)	21.88	43.78	10.92
Sand (of 8.0 to 64.0 millimeters)	32.39	4.57	3.97
Total	96.57	98.18	98.72

"Clay is shown to be present in very small amounts only; there is a good deal of the finest silt (<0.25 mm.), and then there occurs a conspicuous break in the small amount of sediment just above that point."

The water-capacity has been determined for nearly all of the soils of the State that have been chemically analyzed, but for the present purpose of studying this property with respect to both the physical and chemical nature of the soil, only such are taken for discussion as have had the proportion of mechanical ingredients determined.

These are comprised in the following table, and are arranged according to general character of *clay soils* having 20 per cent and above of clay, *clay loams* with 15 to 20 per cent of clay, loams with 10 to 15 of clay, *sandy loams* with 5 to 10 of clay, and *sandy soils* with less than 5 of

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clay, the soils of each division arranged according to the respective water capacities. The other columns show respectively the percentages of "clay," and of clay combined with other ingredients of increasing hydraulic value, as determined in the analysis.

In these determinations uniformity is preserved with the methods of mechanical and chemical analysis by using only the material that has a diameter of less than half a millimeter.

Method Used.—The method of capacity determination used was that suggested by Professor Hilgard in Bulletin 38, Division of Chemistry, U. S. Department of Agriculture. A circular brass box with perforated bottom, containing exactly 25 cc. and holding a column of soil 10 mm. height, is filled with the air-dried soil, which is settled by a gentle tapping of the box on the table. The surface is then struck off level by a thread of silk and the box and soil weighed. It is best to rest the box upon a glass plate, both when weighing dry and when wet, to protect the scale pans.

Place the weighed box and soil on a triangle submerged just beneath the surface of the water in a somewhat wide vessel; allow it to stand until fully saturated (not less than one hour in order to insure the complete wetting of compacted soil particles); then wipe rapidly with filter paper or an absorbent towel and weigh again without unnecessary delay. Calculate from the weighings the results with respect to both weight and volume.

Comparison of Soils by Volume and by Weight.—A glance over the column (the last but one in the table) giving the weights of equal volumes of the various soils shows great differences even in soils of the same class, a difference due to the character of the ingredients. Thus among the clay soils we have weights varying from 78 to 111 grams, with an average of 102 grams per 100 cubic centimeters. Among the clay loams, from 98 to 111, with an average of 108 grams. The loams are still more varied, and reach from 76 to 120, with an average of 100.7. The three sandy loams have an average of 121; while the sandy soils average 129 grams. The coarse sandy soil from Morano, one of the last group, is really representative of another class, for its ingredients are coarser, and its weight is far above any of the others, 157 grams, or 5.5 ounces per 100 cc.

As a general rule the sandy soils are the heaviest, and the loams or soils containing the greatest percentages of light, silty material are the lightest. The soils more clayey in character are somewhat heavier than the loams. The lightest of all the soils of the table is the sediment loam ("slickens") from Sacramento, derived from the tailings from the placer mines of the foothills. It has a weight of only 76.4 grams per 100 ccm., a little less than that of the red ferruginous soil of Grass Valley, which contains 53 per cent of (highly ferruginous) clay.

We thus have altogether very great differences of weight among the soils presented in the table; and this necessarily implies great differences in volume for equal weights of the respective soils. The very light silts would have a volume very much greater than soils of coarse sand, such as the Morano specimen; and the total amount or volume of space between the grains would be correspondingly larger. The capacity for water would thus be greater in the light soils than in the heavy, if such capacity were dependent entirely upon the interspaces. We find such to be the case in the present series of analyses, and soils which should

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naturally be rather low in the scale of comparisons, rise to the first place because of this increase of volume, weight for weight. For instance, the sediment soil No. 10 from Sacramento, is the lightest of all of the soils, and 100 grams occupied a volume probably twice that of the Morano sandy soil; we naturally find, therefore, a capacity of 82 as against 23 for the latter (see table, page 89). On the other hand, if we were to take the water-capacity of equal *volumes* as the unit of comparison, we will have a basis much less subject to variations and consequent errors, though not entirely so. It is altogether the safer of the two, and though both comparisons are given in the following discussion, that by volume takes precedence; the more, as it has the most direct relation to practice.

Changes in Volume.—When in the determinations in the brass sieve-box dry sandy soils have their lower surfaces dipped in water there is usually a sudden flashing of the water over the upper surface because of the rapid rise, and the volume remains about the same. In the more clayey soils, however, the rise is slower, and the appearance of the water on the surface is more irregular, and a longer time is required for complete saturation. In the ferruginous soils, and in some of the loams, there is seen a contraction along the edges just before the water reaches the surface, leaving an open space of about one millimeter; but when fully wet this in most cases closes up and a further expansion may cause the surface to rise above the level of the containing sieve-box. On the other hand, some of the soils were found to contract because of the puddling of their flocculated particles.

A prominent example of expansion is the "*dry bog*" *soil* of Tulare Lake, No. 77; it absorbed water with extreme slowness, and not until after twelve hours was it found to be fully saturated. Its volume had then increased until its surface had reached a height of about three millimeters above the level of the sieve-box, or nearly one third of its previous height. Other soils were also found to increase in volume, though not to the same extent.

On the other hand, we have a most interesting example of contraction in the *Tulare alkali soil*. A sample of the naturally moist though air-dried soil was taken for the test. As soon as the water began to rise from below there was the appearance of large cracks across the upper surface, and the mass began to crumple or fall together as soon as the water appeared on top. When full saturation is accomplished the soil appears as a mass of mush whose surface is some three millimeters *below* its former level. The immediate cause of this puddling and contraction is clearly the effect of the black alkali or carbonate of soda, which had destroyed the cause or causes by which the soil was kept in a flocculated condition. Another sample of the alkali soil which had been deprived of the carbonate of soda by treatment with a gypsum solution and leaching was found to act in the same manner. The soil it would seem, had not had time to recover its flocculated condition. To test this point a sample of soil was used from the original alkali tract which had been reclaimed by the application of gypsum and subsequently placed in cultivation and exposure to weathering, and upon which a fine crop of grain had been produced. The result was that the soil retained its original volume on wetting in the sieve-box, and there was no perceptible contraction; thus indicating a re-flocculation of its particles from natural causes.

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MECHANICAL ANALYSES ARRANGED ACCORDING TO WATER-CAPACITY.

No.	Name.	Locality.	Hygroscopic Moisture.	Water-Capacity by Volume.	Mechanical Analysis.						Chemical Analysis.		Weight of 100 c.c. (6.1 cub. ins.) of Soil.	No.
					Clay.	Clay Combined with Silts.				Sand.	Soluble Silicates	Soluble Matter.		
						To 0.25 mm.	To 5 mm.	To 1 mm.	To 2 mm.					
	CLAYS.												Grams.*	
77	Dry bog soil	Tulare Lake	10.38	76.7	29.79	45.2	47.4	55.6	64.2	22.1	18.0	34.0	111	77
643	Black waxy soil	Colton Ranch	13.51	68.0	43.54	79.1	81.7	84.8	87.5	7.2	28.4	39.5	105	643
68	Adobe soil	Chinese Camp	11.19	64.0	26.10	62.5	65.5	70.3	76.3	21.4	34.2	43.2	107	68
9	Alkali soil	Stockton	2.63	63.9	24.60	54.0	63.5	69.7	75.9	21.7	.....	.....	108	9
6	Black adobe soil	Stockton	14 53	60.9	32.63	74.0	79.5	85.1	87.1	9.1	22.3	29.1	110	6
789	Upland adobe soil	Mission San José	9.74	60.8	34.16	54.0	56.6	58.1	61.7	33.1	15.0	18.8	105	789
188	Red mountain soil	Sonoma	13.70	58.3	52.24	67.9	71.8	77.9	82.4	14.4	26.9	52.9	97	188
1	Black adobe soil	University	7.52	58.0	31.93	57.7	61.1	65.9	73.4	22.9	16.7	21.4	91	1
8	Non-alkali soil	Stockton	9.18	55.6	20.80	56.1	62.7	68.3	75.6	20.8	.....	.....	107	8
676	Volcanic soil	Clear Lake	11.11	55.0	29.84	61.2	64.9	70.9	76.9	21.9	.....	.....	101	676
863	Red soil	Grass Valley	14.20	53.7	24.78	57.1	59.5	65.3	71.0	26.2	54.0	62.3	78	863
110	Alluvial soil	Putah Creek	10.32	53.4	31.49	76.8	80.4	85.4	89.8	5.4	20.7	28.7	102	110
2	Black adobe soil	University	5.14	53.2	33.53	61.7	67.6	74.6	81.0	14.0	24.1	31.3	101	2
1679	Adobe soil	University	11.98	50.4	44.27	69.6	73.2	77.7	83.1	12.4	.....	.....	110	1679
506	Colorado bottom soil	Colorado River	9.26	48.4	23.97	55.8	67.1	79.7	88.1	3.6	16.4	37.0	86	506
1655	Red vineyard soil	Crabbs, Oakville	4.25	47.4	21.73	58.5	63.0	68.5	75.7	21.1	19.1	26.8	107	1655
986	Sandy adobe soil	Cupertino	5.10	46.6	20.54	48.2	52.1	55.6	59.9	36.8	13.2	19.9	111	986
	CLAY LOAMS.													
1645	Alluvial soil	Kells, Yuba City	5.27	59.9	15.30	58.8	68.9	77.1	85.4	12.7	23.7	32.4	103	1645
67	Mining slum soil	Chinese Camp	10.26	53.9	18.47	46.7	54.9	65.5	77.5	18.7	18.1	27.4	106	67
1663	Red mesa soil	Riverside	5.06	53.2	19.37	37.2	41.4	53.6	72.1	25.6	.....	.....	111	1663
1647	Redwood soil	Guerneville	5.14	52.3	16.54	37.0	40.4	44.5	51.7	45.2	18.4	24.2	103	1647
1113	Red foothill soil	Amador	6.00	49.6	16.43	51.3	61.3	69.0	77.2	20.0	23.8	35.3	98	1113
4	Adobe ridge soil	University	5.18	49.0	18.92	41.0	47.8	57.2	63.8	32.1	11.0	15.0	105	4
168	Valley silt soil	Santa Paula	5.49	46.4	15.02	30.2	35.3	43.3	56.0	45.5	8.6	11.9	131	168
	LOAMS.													
10	Sediment soil	Sacramento	9.18	63.0	12.06	55.6	68.7	82.4	92.7	3.5	25.1	31.4	76	10
1284	Moist land soil	Chino Ranch	5.81	60.2	13.44	35.5	40.4	46.4	59.9	35.9	13.6	28.8	102	1284
586	Plains soil	Outside Creek	4.86	49.8	10.48	34.9	37.1	47.7	53.9	43.3	16.5	22.2	105	586
1115	Granitic soil	Amador	5.93	48.9	11.86	32.8	36.1	40.0	45.9	52.2	21.0	26.3	91	1115
51	Red foothill soil	Auburn	3.17	48.4	13.91	45.8	51.4	62.8	78.8	14.9	18.2	31.6	97	51

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130	Reddish loam	San Gabriel Valley	2.30	45.0	10.70	27.3	33.9	39.0	46.1	50.4	13.1	19.4	113	130
1167	Black lands soil	Tulare	5.38	44.4	14.65	38.9	44.4	47.9	54.9	42.6	16.2	21.2	106	1167
1055	Red sandy loam	Fresno	3.62	44.2	11.01	29.9	36.4	44.9	57.6	42.4	13.4	20.9	120	1055
1678	Sandy alkali soil	Tulare	6.41	33.0	10.42	45.3	48.1	54.6	62.3	31.5	------	------	96	1678
	SANDY LOAMS.													
1281	Mesa soil	Chino Ranch	1.98	44.7	7.60	26.1	31.6	35.5	41.9	50.8	13.4	22.5	118	1281
1159	Sandy plains soil	Tulare	4.00	43.6	5.71	16.7	20.8	26.3	33.4	63.7	13.7	20.6	116	1159
1147	Sandy loam soil	Paso Robles	1.84	37.1	7.40	25.2	31.2	39.8	48.2	50.5	5.8	9.6	129	1147
47	Red mesa soil	National Ranch	2.30	22.9	9.66	21.0	24.2	28.0	33.9	65.1	9.6	13.3	------	47
	SANDY SOILS.													
1148	Swale soil	Paso Robles	3.43	44.4	3.09	24.6	27.8	38.1	45.9	51.6	6.7	10.0	107	1148
1197	Gila bottom soil	Gila River	3.48	42.3	3.21	8.7	10.7	13.9	24.1	72.1	8.9	23.1	124	1197
1595	Sandy soil	Castroville	1.15	37.6	2.60	8.9	9.2	12.7	13.6	83.6	------	------	127	1595
233	Sandy soil	Morano	.79	37.5	2.82	5.2	6.0	6.5	8.7	89.9	------	------	157	233

* 100 grams is equivalent to about 3.5 ounces avoirdupois.

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A practical lesson from this experiment is that in the reclamation of alkali lands, the mere application of gypsum will not alone restore the soil to its former tilth, but that the restoration of its flocculated condition by time and by tillage is all-important.

Comparison of Results.—In the accompanying table the soils are arranged in each group in the order of water-capacity by volume. A summary of mechanical ingredients and chemical composition and of hygroscopic moisture, is given, together with the weight of 100 cubic centimeters of each air-dried soil.

It might naturally be expected that the proportion of colloid "clay" in a soil would govern the amount of water held within its pores, and to a certain extent this seems to be the case, but is by no means a consistent rule. In fact, a study of the tables shows that we cannot rely upon this material as a basis, for many of the loams have higher capacities than the clay soils, and even the sandy swale soil of Paso Robles with its 3 per cent of clay holds more water than the soil of Cupertino with its 20 per cent. Again, the Tulare dry bog soil with about 30 of clay holds nearly 77 of water, while the Sonoma red mountain soil with 52 of clay holds but about 58 of water. In fact there are in the table nine soils which with a greater amount of clay hold far less water than the "dry bog" soil, No. 77, with only 29.8 of clay. Such instances could be cited in large number from this table alone; and to rearrange the table without groupings, so that the figures in the column of clay should read consecutively from highest to lowest parallel with the water-capacities, there would be required a movement through 200 points.

In the sixteen *clay soils* of the table, or soils having above 20 per cent of clay, the percentages run from 20 to as much as 52 of clay, the average being 31.1; while the water-capacity is from 46.6 to 76.7, with an average of 57.3. The soil having the highest water-capacity is that of the "dry bog" of the old border of Tulare Lake. Water when applied to it passed upward with extreme slowness, requiring twenty-four hours for complete saturation; in the meantime the volume had increased greatly by expansion. The high water-capacity is evidently not due to its "clay" and fine silt, for these are relatively small when compared to soils of a lower capacity. Neither is it especially rich in soluble matter, or even in humus, which doubtless has much influence in this as well as many other soils of high capacity. It may be due, in part at least, to the increase in volume, which of course adds that much to the interspaces and permits the absorption of more water; but what causes the increase in volume?

The same is true of the two soils which stand next in order of highest capacity, the adobe of Colton ranch, No. 643, and the adobe of Chinese Camp, No. 68, whose expansion was each fully two millimeters above the level of the sieve-box. The alkali soil of Stockton, No. 9, which ranks next, also expanded somewhat, but not to the same extent as the others.

In mechanical composition these last two soils (the Chinese Camp adobe and the Stockton alkali) are almost identical, except that the former has a little more clay; we find that they have almost the same water-capacity. In other clay soils, however, where the mechanical composition is very nearly the same, we find large differences in capacity, evidently from other causes. On the other hand, there are soils

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having the same capacities (red mountain soil of Sonoma and the University adobe), which differ widely in composition, both mechanical and chemical; thus showing plainly that the mechanical composition, as our analyses thus far define it, does not alone govern the capacity of a soil to absorb water.

The seven *clay loams* have water-capacities varying from 59.9, the highest, to 46.4, the lowest, the average being 52 per cent. They have an average of 17.2 of clay, and although all are lower in clay than the clay soils, we find all but one having a water-capacity greater than some of the latter.

The Sacramento alluvial soil of Kells, near Yuba City, has the largest capacity (59.9) of the group, and is above the majority of clay soils in this regard. The reason for this is not immediately apparent, for the proportion of fine earth is not relatively high; it may, as in other cases, rest with the soluble silicates.

The ordinary *loams* have clays running from 10.4 to 14.7, with a general average of 12 per cent; their water-capacities are from 33.0 to 63.2, the average being 49.6. It is thus an incongruous group so far as water-capacity is concerned. It is interesting to note that the sediment soil from Sacramento, with only 12 per cent of clay, has a capacity of 63.0, or far above the clay soils, whose clays are nearly three times as great in amount. According to its chemical analysis it is very rich in hydrous silicates, probably 35 per cent, and to this it doubtless owes its high capacity for holding water.

The naturally moist soil, No. 1284, of the South California Station, Los Angeles County, is also above the majority of the clay soils in water-capacity. It contains some 29 per cent of soluble silicates and quite a large amount of humus (2 per cent), which must have some influence.

The *sandy loams*, with from 5.7 to 9.6 per cent of clay, have an average water-capacity of 30, or from 22 to 37.1. Some of them are above the ordinary loams in this respect, but none worthy of special note.

The *sandy soils*, with less than 5 per cent of clay, are fully equal in water-capacity to the more loamy specimens of the preceding group, and one of them, the swale soil of Paso Robles Station, stands above several of the loams proper with more than 10 per cent of clay. The Morano specimen, No. 233, which may be regarded as a typical sandy soil, with nearly 93 per cent of sand and coarse silt, will hold but 37.5 per cent of water, and this is the lowest in capacity, except two, in the entire list of forty-one soils. The exceptions are the sandy loam of Paso Robles and the red mesa soil, No. 47, of San Diego County, which though having about 10 per cent of clay, each have capacities of but 37.1 and 21.9, respectively. The reason for this is not yet clear.

The proportion between the clay and the finest silts affects very greatly the water-capacity, for when the former is in quantity just sufficient to bind the particles of silt when wet, it will produce what is known as "putty soils." A larger amount of clay affords an excess above what is needed for binding, and this excess of flocculation among its particles tends to break this union and produce looseness. The swale soil, No. 1148, from the experiment station at Paso Robles, is an instance of these putty soils. It is made up of 42.8 of silt, 49.9 of sand, and but 3.09 per cent of colloid clay, and would therefore naturally be placed among the sandy soils; but the proportion of clay is just sufficient to fill the interspaces of the silt, and when wetted, cause these to

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closely adhere, producing a putty condition while wet, and a compact, solid, rock-like mass when dry. (The sample of this soil, 3x4x36 inches, taken in this latter condition for the World's Fair, reached us from the return trip across the continent in the same solid form, while the other samples were much broken up.) When wet it packs closely and naturally retains more moisture than if it were a little more porous; it forms "boggy" tracts dangerous to teams. The Gila River soil, No. 1197, has very nearly the same amount of clay, but its proportion of silt is less and that of coarser sand much greater; we do not, therefore, find the same adhesiveness among the particles, nor the peculiar properties when wet.

WATER-CAPACITY BY WEIGHT.

Two methods were used in the determination of water-capacity by weight. That at first employed has proven to be unreliable and has been discarded for the newer method. In it, 100 grams of air-dried soil was placed into a funnel containing a filter (whose average water-capacity had previously been ascertained), and water allowed to flow on top from a graduated pipette until thorough saturation or until it passed through, the excess from drippings being returned to the pipette; the amount of water was thus quickly determined. It was found that the method was open to serious and even fatal errors. First, the height of the column of soil in the filter, 30 to 50 millimeters, was so great as to create serious errors, due to the differences in total capillary ascent, to which the conical column in the funnel bears no sensibly constant ratio. Second, the filter, itself a source of error, also acted as a carrier for the water when, by reason of physical or chemical properties in the soil, percolation was very slow, and thus full saturation in the center of the soil was prevented. In a number of soils the water-capacity is found to be greater than by the newer method, the reason for which is not apparent, but perhaps due to the filter. The results by this method are given in the table below for comparison with that by other methods. The method now used is that of the sieve, suggested by Professor Hilgard in the determinations by volume, by which the saturation is accomplished by capillary ascent of the water, in a column of soil 10 millimeters high. Results are given in the following table:

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WATER-CAPACITY BY WEIGHT.

Number	Name.	Locality.	Water-Capacity Percentage. By Weight. Sieve.	By Weight. Funnel.	By Volume. Sieve.	Weight of 100 Cubic Centimeters of Soil.
	CLAY SOILS.					Grams.
77	Dry bog soil	Tulare Lake	68.9	79.6	76.7	111
863	Red soil	Grass Valley	68.8	61.4	53.7	78
643	Black adobe	Colton Ranch	64.6	70.3	68.0	105
1	Black adobe	University	63.5	61.4	58.0	91
68	Adobe soil	Chinese Camp	59.8	70.8	64.0	107
188	Red mountain soil	Sonoma	59.6	44.9	58.3	97
9	Alkali soil	Stockton	58.9	64.0	63.9	108
789	Upland adobe	Mission San José	57.8	50.7	60.8	105
506	Bottom soil	Colorado River	55.6	46.5	48.4	86
6	Adobe soil	Stockton	54.9	47.1	60.9	110
676	Volcanic soil	Clear Lake	54.4	.....	55.0	101
2	Black adobe subsoil	University	52.4	46.0	53.2	101
110	Alluvial soil	Putah Creek	52.4	50.0	53.4	102
8	Non-alkali soil	Stockton	52.1	54.0	55.6	107
1679	Adobe soil	University	46.0	44.4	50.4	110
1655	Red vineyard soil	Crabbs, Oakville	44.3	45.0	47.4	107
986	Sandy adobe	Cupertino	42.0	39.0	46.6	111
	CLAY LOAMS.					
1645	Alluvial soil	Kells, Yuba City	58.4	44.3	59.9	103
1113	Red soil	Foothill Expt. Sta.	52.3	47.5	49.6	98
67	Mining slum soil	Chinese Camp	50.7	52.2	53.9	106
1647	Redwood soil	Guerneville	49.9	45.0	52.3	104
1663	Red mesa soil	Riverside	48.0	42.6	53.2	111
4	Adobe ridge subsoil	University	46.6	45.7	49.0	105
168	Valley silt soil	Santa Paula	38.7	33.1	46.4	131
	LOAMS.					
10	Sediment soil	Sacramento	82.3	63.2	63.0	76
1284	Moist land soil	Chino Ranch	58.8	54.7	60.2	102
1115	Granitic soil	Foothill Expt. Sta.	53.8	42.5	48.9	91
51	Red soil	Auburn	49.7	45.3	48.4	97
586	Plains soil	Outside Creek	47.3	34.2	49.8	105
1167	Black lands soil	Tulare	41.7	38.3	44.4	106
130	Reddish loam	San Gabriel Valley	40.7	39.7	45 0	113
1055	Red sandy loam	Fresno	36.9	39.6	44.2	120
1678	Alkali loam	Tulare	34.2	32.0	33.0	96
	SANDY LOAMS.					
1281	Mesa soil	So. Cal. Expt. Sta.	37.9	33.4	44.7	118
1159	Sandy plains soil	Tulare	37.4	36.5	43.6	116
1147	Sandy loam	Paso Robles Expt. Sta.	28.7	28.5	37.1	129
47	Red mesa soil	National Ranch	.....	21.9	22.9	.....
	SANDY SOILS.					
1148	Swale soil	Paso Robles	41.5	40.9	44.4	107
1197	Bottom soil	Gila River	34.8	32.0	42.3	124
1595	Sandy soil	Castroville	29.7	31.2	37.6	127
233	Coarse sandy soil	Morano	23.0	24.3	37.5	157

Soils of Light Volume-Weight.—It will be seen by comparison with the former table, that in nine soils the capacity by weight is greater than that by volume, and that in each of these the reason lies in the fact that the soil is light in weight, giving greater bulk weight for weight; and while the actual amount of water by volume is not affected, the percentages calculated upon the soil weight is greater than if the soil were heavier. The weight of the soil is, in all these cases, less than 100 grams per 100 cubic centimeters; all other soils are above that in weight.

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Again, the lightest soils have the greatest differences between capacity by volume and that by weight. In the sediment soil of Sacramento, the lightest of the series, and which has the highest capacity by weight, the difference is 19; in the red soil of Grass Valley, the weight of which is a little greater, the difference is 14; the bottom soil of the Colorado River, the next in weight, has a difference of 7 per cent; and the University adobe, No. 1, and granitic soil of the foothills, having the same weight, have also the same differences of 5 per cent; the others of the group of nine are less than this.

Change of Relative Position.—It will also be noticed that in the order of arrangement from highest to lowest, the relative positions of many of the soils in the clay, clay loam, and loam groups have been changed from that of the table of percentages by volume. The dry bog soil, No. 77, maintains the first place, the Grass Valley soil becomes second instead of eleventh, the University adobe fourth instead of eighth; the reasons have already been given. In the sandy loams and sandy soils the order of position remains the same.

Collapse Caused in Alkali Soils.—It is worthy of note here that when water was applied to the dry bog soil No. 77, in the funnel, several hours elapsed before it appeared below, and that the mass finally became a fine mush, quite in contrast to its condition when saturation was effected by capillary water from below in the sieve. This mushy condition assumed with water, is due to the puddling of the particles of earth, a breaking up of their flocculated condition, and precipitation into a mass so compact as to prevent the percolation of water. This phenomenon is due to the presence of ("black") alkali or carbonate of soda in the soil, as shown by the chemical analysis, and is characteristic of all such alkali soils, and by which are produced the hog-wallows or swales on the surface of spots thus affected.

Direct experiments to determine the changes caused by such puddling of clay, by means of carbonate of soda, in other soils, will be made in the near future.

Conclusion.—Without closely comparing the results of the above table it may be remarked that while in some the water-capacity seems to be largely controlled by the amount of fine material (clay and silts); there are others affected chiefly by other causes, for, while their water-capacity is practically the same, they differ very greatly in mechanical composition, as is also shown when considering the capacity by volume. Thus the sandy swale soil of Paso Robles, with its 3 per cent of clay, has about the same capacity as the Cupertino sandy adobe with its 20 per cent of clay; neither is there much difference in weight of the two soils. The alkali soil of Stockton and the Chino moist land soil have about the same capacity, and yet the one has nearly twice as much clay and much more fine earth than the other; there is again but a slight difference in volume-weight.

As a class, the clay loams, with from 15 to 20 per cent of clay, equal and in few cases surpass in capacity the majority of clays with from 20 to 29.8 of clay. The ordinary loams in turn, with only 10 to 15 of clay, equal the clay loams, and in two of the soils surpass them in capacity.

So that altogether, whether we estimate the water-capacity with reference to volume or to weight, we arrive at the same conclusion, viz., that the capacity of a soil to hold water is not alone controlled by the amount of the clay and fine material that enter into its composition, but

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that the character of that clay and silt, both chemical and physical, and the presence of certain compounds, exercise a very large, and in most cases, a controlling influence.

In considering a number of the extreme cases in point we are led to the suggestion that the hydrous silicates (and other hydrates) other than clay are intimately concerned with this property, and that the important part which they play, from a chemical point of view, as repositories of plant food, appears to be supplemented by a no less important influence upon the physical characters of the soil.

THE CAPILLARY RISE OF WATER IN SOILS.

The height to which water will rise by capillary movement in soils from underground irrigation water, and the ease with which it is thus transmitted in all directions, is a matter of vital importance to all vegetable growth, especially in regions of scanty rainfall. This property in a soil is dependent largely upon its physical condition, and as it is sandy, silty, loamy, or clayey, the water has a greater or less freedom of movement in all directions.

It is well known that water percolates through a sandy soil with greater ease and rapidity than through silt or clay, because of its more open character, and the consequent less resistance offered by friction. Clays, on the contrary (unless the particles are in a flocculated condition, thus presenting open interspaces), are so closely united as to afford but little opportunity for the passage of water. Then, too, the strong attraction of clay for water and the very high tenacity with which it holds on to that first absorbed, renders it almost impossible for a column of water to force its way rapidly downward to lower depths, or to either side.

The same is true of the next material, the silts, but to a less degree, and is largely governed by the chemical nature; a silty soil of extreme resistance to the passage of water has already been alluded to on page 81. The downward movement is naturally the greatest and most rapid; the lateral is less so, while that upward is the slowest of all, and its limit, as well as rapidity, is controlled by the physical and to some extent by the chemical character of the soil.

The capillary power in a soil, or that power which draws liquids upward against the opposing or downward force of gravity, is governed by the size of the spaces between the particles. This is of course greater in sandy than in clayey soils, and even in loams, where the spaces between the sand grains are filled with those of clay. In the former there is greater freedom of motion, but also a smaller tension of the relatively large water surfaces in the interspaces; hence we find that in these soils, while rising rapidly, the capillary water may not reach more than a few inches in height. In loam and clayey soils in which these surfaces are not so large, but their tension greater, the height to which the water ultimately rises is far greater, though in consequence of friction, much slower. The extreme height thus far attained in the experiments made is 50 inches, even after a period of 225 days.

Method of Examination.—The old method of using a glass tube has been changed to that of copper tubes one inch in diameter, in sections of 12 inches, made to fit together; one side of the tube left open and flattened to receive a piece of glass plate, which is held in position by rubber

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bands and made tight to the tube by paraffine to prevent sifting of the soil. Three objects are thus gained: any length of tube can be used by simple adjustments, the soil can be properly filled in, and, when the experiment has been completed, an examination of any portion of the soil column can be made to ascertain the percentage of water held at different heights above the surface, or for other objects. A muslin cloth is fastened over the lower end of the tube to prevent escape of the silt, and the tube is ready for filling.

The filling-in of the soil requires care and special precautions, for it is found that if it is simply poured in from the top, the soil adjusts itself in irregular layers by levigation, the larger particles arriving before the lighter ones, and thus producing segregation into layers, and that the water rises irregularly and presents a very irregular and zigzag horizontal line, and thus preventing close reading. This irregularity is largely prevented by the use of a stiff wire, the lower part bent into a corkscrew spiral 6 or 8 inches long and nearly of the diameter of the tube itself. The soil is poured into the tube in successive portions, each filling it to the top of the wire spiral, which is then turned as if to make it enter, but at the same time gradually withdrawn; this thoroughly breaks up any tendency to stratification and leaves it in a uniform condition. A column of about 30 inches is thus prepared and somewhat tamped by slight tapping on the table. If necessary, other tubes may be added and filled later in the experiment, as the water rises. A graduated scale is then attached to the side of the tube, which is placed upright on a perforated bridge in a water reservoir; the latter is then filled with water to the zero point of the scale. Frequent readings of the rising water-line are then made and recorded.

The soils selected for the experiment were of distinct physical characteristics, and the examinations were made at different times; the results of some of them have already been given in the Report for 1892, but are reproduced here for convenience of comparison with those more recently made. They comprise the following:

No. 1197, bottom alluvial soil of Gila River.

No. 233, sandy soil of Morano, Stanislaus County.

No. 168, silty soil of Santa Paula, Ventura County. This was tested in both the tilled and the tamped condition.

No. 1679, adobe soil from the University grounds, Berkeley, Alameda County.

No. 1678, sandy alkali soil from Tulare. This was tested first in its natural or moist condition, then when dry, and then after its alkali had been changed to the sulphate by treatment with gypsum solution and leached out.

The following table gives the percentage of mechanical ingredients forming each soil:

	Clay.	Silt.		Sand.
		Fine.	Coarse.	
No. 1197. Gila bottom soil	3.21	5.53	15.42	72.05
No. 233. Morano sandy soil	2.82	3.08	3.49	89.35
No. 168. Ventura silty soil	15.02	15.24	25.84	45.41
No. 1679. Berkeley adobe	44.27	25.35	13.47	13.37
No. 1678. Tulare sandy alkali soil	10.42	24.81	16.96	41.62

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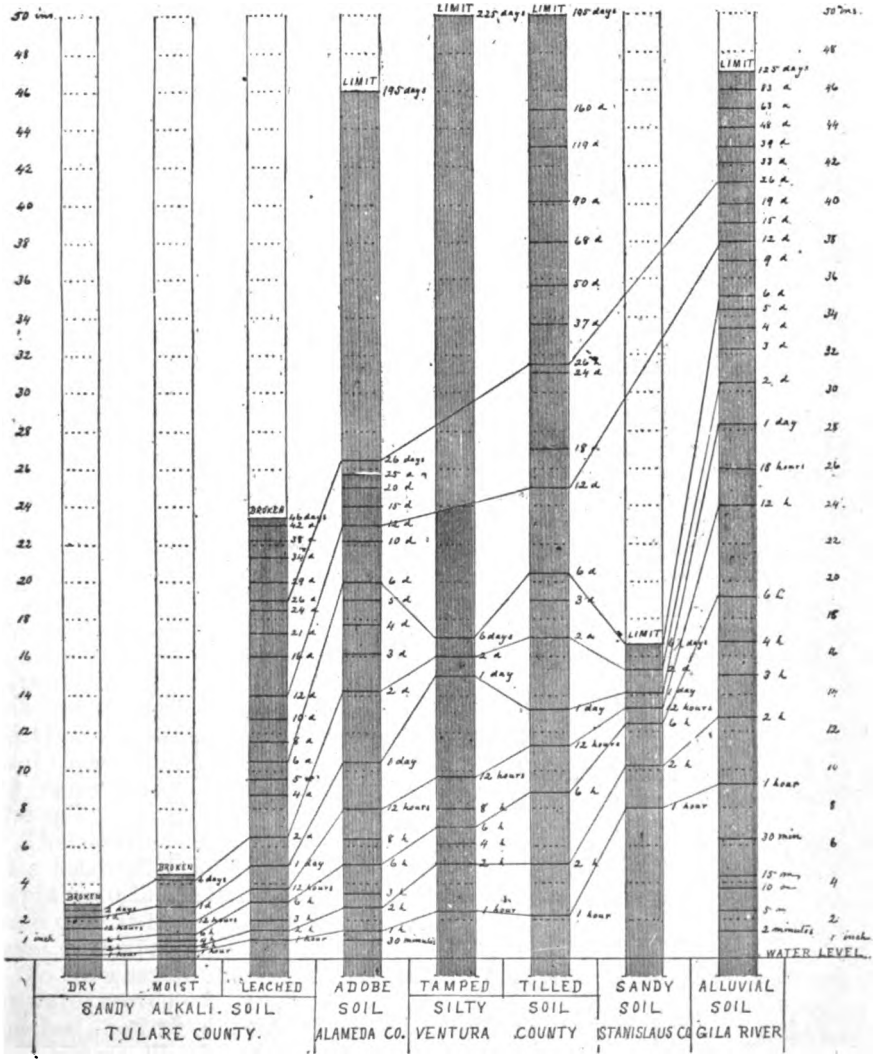
The accompanying diagram represents the upright columns of soil, marked to show the rapidity with which the water rose in each column, and the extreme height attained. The columns are arranged from right to left in the order of rapidity of ascension, and the lines connecting the points of equal heights serve to enable the eye to quickly take in the variations. Unfortunately in the early experiments with three of the columns (Alameda and Ventura soils) no time record was kept of the higher portions of the columns, and comparisons cannot be made with these. ' All of the samples were air-dried when placed in the tubes, except that one of the alkali columns was deprived of its natural moisture by drying at 100° for comparison with the moist column. The columns are shaded to the point reached by the water.



Columns showing heights to which water will rise by capillarity in soils of different physical composition.

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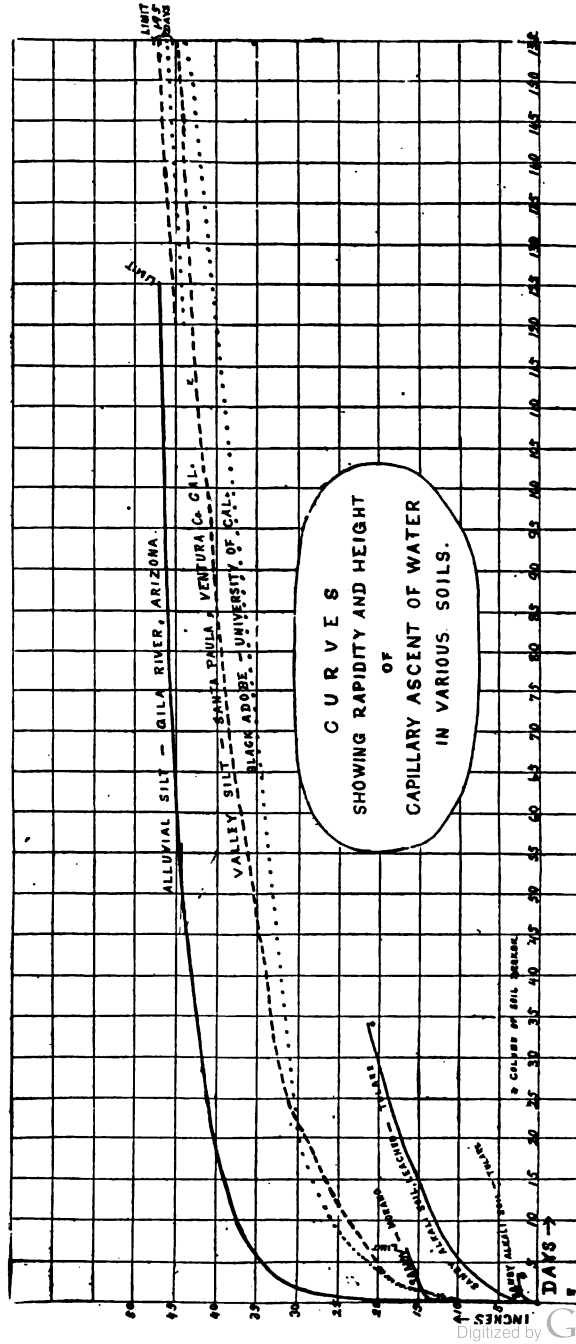
Graphic Curves.—Another method of illustrating the differences in rate of ascent of water in the several soils is that of curves through spaces in which the vertical represent equal heights in inches, and the horizontal spaces represent length of time in days, as shown in the accompanying cut.



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The alluvial soil of Gila River, because of the very great rapidity of ascent on the first day, stands above all the others; the Ventura silt next, having crossed the path of the adobe after 20 days. The alkali soil is lowest of all in the scale, doubtless in consequence of the infinitesmal subdivision of its particles by puddling, and the total absence of flocculated structure due to the presence of sodic carbonate.

COMPARISON OF THE RAPIDITY OF WATER-ASCENT IN THE SOILS.

The Gila River alluvial and the sandy Morano soils are each very sandy, and the water, finding but little clay to obstruct its passage, rises very rapidly for a certain distance in each. The relatively large water-mass between the grains of sand in the Morano soil, however, yields to the force of gravity, and the water soon ceases to rise. In the Gila soil, however, these spaces between the coarse particles are filled with 21 per cent of silt (only 6.5 in the Morano), and thus by making a smaller tension-surface (meniscus) between the grains, the capillary force remains superior to that which pulls downward, and the water is enabled to rise to the height of 47 inches above water-level. In the Gila River soil the grains of sand are not as coarse as in the Morano sample, and this also has its influence in increasing the capillarity of the former.

The Tulare sandy alkali soil and the Ventura silty soil are nearly alike in physical composition, and should therefore have about the same capillary power, if the mere soil particles are to be considered. They each contain practically the same amount of silt (41 per cent), and the clay in each is not very high. The differences in capillarity are, however, very great at the intervals of time recorded, and clearly show that the power in a soil to transmit water upward is not entirely due to the size of the particles, but to other causes, such as probably the presence of certain soluble salts which change the condition of the soil. In the present instance the retarding effect of the small per cent of carbonate of soda in the alkali soil is plainly seen. Had the column not broken, the water in the alkali soil would probably have finally reached very nearly the height of fifty inches attained by the silty soil, though after a much longer time.

Sandy Alkali Soil.—The column having the slowest capillary water movement is the dry, sandy alkali soil from Tulare. The dark line marking the ascent of water reached the water-level from below only after many minutes had passed; and then at the end of an hour it had reached a height of one fourth of an inch, and in six hours only an inch. In two days, when the column broke because of the puddling of the clay and contraction of the wet mass, the water had reached a height of only 2¾ inches, and even then only after repeated trials of a fresh column of the soil.

The moist alkali behaved somewhat better, but also broke in two days, at a height of 4½ inches above water-level. The rise was somewhat more rapid than in the dry sample, though still extremely slow, reaching an inch only at four and one half hours after it had appeared at the water-level in the reservoir.

To see what influence, if any, the soluble alkali salts had upon the upward movement of the water, a sample of the soil was thoroughly leached, and thus freed from alkali, was dried and put in the tube. Improvement was very perceptible, though not specially so; the water

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rose seven eighths of an inch in an hour, and 6½ inches in two days—about 2 inches more than in the moist unleached condition.

A marked feature of the experiment was the fact that the column of the leached soil held for 46 days before a break came; in strong contrast to the two columns of unleached alkali soil, each of which broke in two days. This breakage is caused by the puddling of the soil, by which the particles are released from their flocculated (coalesced into small masses) condition and caused to fall together in a more compact form. This is a prominent characteristic of all alkali soils, and is the effect of the black alkali (carbonate of soda).

The phenomenon seen in a tube is entirely parallel to that observed in every natural "black alkali" spot, which invariably shows a material sinking of the surface below the general level of the surrounding land, and becomes consolidated into sheets of tough hardpan.

The extreme limit of upward capillary movement in this soil was not ascertained, because of the break in the column; but a comparison of its rate of ascent with that of other soils of somewhat similar composition, shows that it is hardly probable that the water-line would have risen higher than 40 inches even in 200 days.

Black Adobe Soil.—The close, heavy-clay character of this soil made the upward movement of water a very slow one, and in one hour the dark line marking its rise had reached but 1½ inches. In twelve hours it had risen but 8 inches, and required twelve hours more to reach 10½ inches. The movement then became very slow, and on the twenty-sixth day, when the detailed record ceased, it had risen but 26 inches, and 195 days were required for it to reach its limit of 46 inches.

Silty Soil.—The silty soil of Ventura County was tested in two conditions, the tamped or compact, and the loose, friable form as given by tillage, in order to ascertain the effect of each upon the capillary power. Unfortunately no record was kept of the rise of the water in the tamped soil after the sixth day. A comparison of the record of each column during the six days is quite interesting, for a glance shows the greater freedom of movement that existed in the loose tilled soil above that of the tamped. The entire height reached was the same in each, 50 inches, but the time required was 195 days for the tilled against 225 for the tamped. For the first two hours the rise of the water was about equal, but at the end of the sixth hour the line marking the limit was 3½ inches higher in the tilled soil. At the end of one day the rise was about even again at 13 inches, doubtless because of some irregularity in the tamping, but afterward the tilled soil again took the lead and kept it so far as the record shows. On the sixth day the difference was 5½ inches.

Sandy Soil.—The sandy soil of Morano, Stanislaus County, showed a rapid rise of 8 inches in one hour, but afterward the rate diminished rapidly, and in six and one half days it had reached its extreme limit of 16½ inches. The spaces between the grains in this soil are so large that the capillary tension that causes the water to rise is soon stopped by the force of gravity, and no further movement occurs.

Gila Bottom Soil.—The alluvial soil of Gila River is remarkable in its power of transmitting water upward by capillary movement. The ascent was extremely rapid at the first, the water making its appearance very quickly above the water-level in the reservoir, and reaching 1½ inches in two minutes, 2½ inches in five minutes, and 6½ inches in thirty minutes.

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In one hour a height of nearly 9½ inches had been reached, in two hours nearly 13 inches, in six hours 19½ inches, while at the end of twelve hours the water had risen 24 inches. At the end of a day the height reached was 27½ inches, and the movement rapidly became slower until the limit of 47 inches was reached in 125 days. This combination of sediments thus appears to be the most favorable for rapidity of ascent.

COMPARISON BY TIME-LIMITS.

To facilitate a comparison of the capillary power of the several soils, the point reached in each at the end of the several periods of time are connected by lines. A glance thus almost instantly shows the great difference, and marks those of the soils in which capillary movement is respectively at the extreme of retardation and of rapidity. We thus have the dry, sandy, alkali soil of Tulare at one, and the light, sandy, alluvial soil of Gila River at the other extreme. While the former required six hours to draw the water up one inch above water-level, the latter soil in the same time had drawn it up 19½ inches. At the end of a day the respective heights were 2¼ and 27½ inches, while at the end of two days, when the alkali column broke, the heights were respectively 2¾ inches and 30½ inches, a difference in rapidity of about 1 to 11.

This great difference between these two soils is in part due to the presence of the carbonate of soda in the alkali, which, as already remarked, produces a puddled condition in the soil as soon as it comes in contact with water, thus preventing a more rapid rise. Other conditions than this, however, tend evidently to produce slow movement in this soil, for when the alkali has been almost entirely leached out the movement is still very slow, though not markedly so. In the first hour the rapidity was but little faster than in the unleached soil, but in the sixth it was at 3 inches as against 1¼; in one day the heights were respectively 5 and 2½ inches, while in two days they were 6½ and 4½ inches.

We must look, then, to both the mechanical and chemical compositions for causes of differences in capillary movement in soils; but in this comparison with other soils of the columns we will omit the alkali feature and take only the leached soil, in order to have all as nearly as possible on the same basis of freedom from excess of soluble salts, and thus be able to draw comparison from a mechanical point only. We thus may follow the rising water in the various types of soils, the sluggish movements in the leached alkali, the adobe, and the silty soils, with the rapidity of the sandy and the alluvial soils.

First Hour.—The water has reached barely 1 inch in the leached alkali soil, 1½ inches in the adobe, 2 inches in the silty soil, while in the sandy and the alluvial it has dashed upward with astonishing rapidity to 8 and 9½ inches, respectively.

Second Hour.—While the movement is still very sluggish in the leached alkali and the adobe, it has gained a little on their next highest competitor and lessened the relative distance between them and the sandy soil to 5 instead of 6 inches. The alluvial soil has in the meantime increased its height with greater relative rapidity and stands nearly 13 inches.

Sixth Hour.—The leached soil has carried its water-line to only 3 inches above the surface, the adobe to a little more than 6 inches, the tilled silty soil to 9 inches. In the meantime the sandy soil is becoming more

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and more sluggish in its capillary power, reaching but 12½ inches, while in the Gila alluvial the water has risen rapidly to more than 19 inches.

First Day.—The extremes at the end of the first day (24 hours) are very far apart, for in the leached soil the water has reached a height of but 5 inches, while in the Gila alluvial soil we find it at 27¼ inches. In the adobe its progress upward was comparatively slow to 10½ inches, while in the silty and sandy soils the water-mark stood at 13 and 14 inches, respectively.

Second Day.—The marked feature of the several columns at the end of the second day was that the water in the Ventura silt had overtaken and risen nearly 2 inches beyond that in the sandy soil, which had nearly reached its extreme limit, but is itself 13½ inches lower than in the Gila alluvial. The height reached in the adobe and in the tamped silt is almost the same, while the leached alkali soil lags far behind and does not reach this height until the thirteenth day.

Sixth Day.—On this day the sandy soil reached its extreme limit of 16½ inches, a point 18½ inches below the alluvial of Gila River. These two results clearly show the very marked difference in capillary power between a coarse and fine sandy soil, for they each have about the same proportion of fine material; but in the sandy Morano soil the proportion of very coarse sand is much the greater, and thus presents relatively much wider spaces between the grains; a natural result is that gravity checks the upward movement quicker than in the finer sands of the Gila soil.

Twelfth Day.—At this time the water in the Ventura silt has gained on that of the adobe, and has also lessened the relative distance between itself and the alluvial of the Gila River; which shows a steady and good movement upward on the part of the Ventura silt water as against a strong slowing-down in the Gila alluvial and other soils. The distance between the limits in the adobe and the leached alkali is relatively the same as at the end of the first day.

Final Limits.—The silts, both tamped and tilled, proved to have the highest capillary ascent, the water reaching a height of 50 inches in 225 and 195 days, respectively; in these is seen the fact that tamping or allowing the soil to become hard serves to retard the rise of water, and that on the contrary, when by tillage the soil becomes loose, the rise is much more rapid, because of the greater freedom to move between the flocculated particles.

The water in the alluvial soil of the Gila River reached its extreme limit of 47 inches in 125 days, having required 42 days to pass through the last inch. Throughout its course the movement of water has been very rapid until the last few inches. In this sudden slowing-down it strongly resembles the sandy Morano soil, which came to a sudden stop early in the race because of its open, sandy nature.

In comparing the rate of ascent at the last in the Ventura silt and the Gila alluvial we notice that the water rose 5 inches in 35 days in the former as against 1 inch in the latter soil in 42 days, or as 7 to 42. There is therefore strong reason to believe that the water would have risen higher than 50 inches in the silt had a greater length of time been allowed.

The water in the adobe worked its way slowly upward until it reached its limit of 46 inches in 195 days.

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PERCENTAGE OF CAPILLARY WATER AT VARIOUS HEIGHTS IN THE COLUMN.

In order to determine the amount of water held by the soil at various heights after the capillary experiment was concluded, the separate pieces of glass were removed from the front of the soil-tube, and portions of the soil transferred to the ground-stoppered weighing-tube as quickly as possible, and weighed; they were then dried at 100° and again weighed, the loss representing the amount of water held. In this manner the water in several of the columns was determined with the following percentage results:

Percentage of Water Held at Various Heights.

Height Above Water-Level.	Gila Alluvial. 1197.	Morano Sandy Soil. 233.	Adobe. 1679.
47 inches	4.33		
42 inches	10.26		
36 inches	11.99		
30 inches	15.26		
24 inches	21.39		10.26
18 inches	27.63		29.48
12 inches	32.48	3.93	33.04
6 inches	35.04	14.15	38.47
3 inches			38.94
1 inch	36.64	24.34	44.41

As was to be expected, there is a rapid decrease in amounts from below upward, but the rate was not at all uniform. In the Gila soil, for instance, there is a difference of 1.6 in the first six inches, 2.6 between six and twelve inches, 4.8 between twelve and eighteen, 6.3 between that and twenty-four, 6.1 to thirty, 3.3 to thirty-six, 1.7 to forty-two, while thence to the top there is 5.9 per cent difference or falling-off in the amount.

The same irregularity is noticed in the adobe, which for each six inches upwards reads 6, 5, 3, 19, showing in each soil at the last a sudden and great decrease in the amount of water. On examination of the adobe soil, it was found that the earth immediately above the line colored by the water had a tendency to adhere, though not wet; a sample of this was found to contain 4.47 per cent of moisture, while that which was apparently dry an inch above it had only 1.94 per cent. It would seem, then, that a large proportion of the water at the top of the column, not having reached its greatest height, had a surplus which enabled it to go further; but finally the film becomes too thin to rise any further, and the moisture above is simply from evaporation.

GENERAL CONCLUSIONS.

From the foregoing data we may draw the following conclusions in brief:

1. The power possessed by soils of absorbing moisture from the atmosphere and to hold water within their pores is not proportionate alone to the amount of combined surface presented by the particles of the soil; and while, as a *very general class*, soils with large percentages of clay and fine silts have a high moisture and water-capacity coefficient, such materials by no means control that power, simply because of large surface area; for even in the small number of soils represented in the

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above analyses there are many which, though having very high clay percentages, are low in their moisture and water coefficient, and *vice versa*.

2. There are in the soil certain chemical compounds (zeolites, ferric, silicic, and aluminic hydrates and humic compounds), which are highly hygroscopic and absorptive in themselves, and are held almost exclusively by the clay in greater or less amounts. The proportion of these, singly or conjointly, seem to have a greater, if not a controlling, influence over that power than the mere amount of clay and fine material, as such.

3. The upward movement of water in soils is controlled in rapidity by the proportion of coarse material; and the limit in height to which water will rise by capillarity is dependent upon the amount of fine silt and clay. The extreme height reached thus far, under the most favorable conditions, is 50 inches, even after several months. In sandy soils the limit was less than 18 inches.

4. The presence of alkaline salts in a soil produces a puddling or deflocculation of the particles when wet, and a consequent compact condition, which prevents the rapid rise of water. This puddling is accompanied by large contraction of volume, a feature which to a far less degree has been observed in other soils. On the other hand there are some soils (adobes and certain ferruginous clays), which, when wet, expand quite considerably, because of the swelling of the colloidal particles.

THE RELATIONS OF SOILS TO CLIMATE.*

By E. W. Hilgard.

Since soils are the residual product of the action of meteorological agencies upon rocks, it is obvious that there must exist a more or less intimate relation between the soils of a region and the climatic conditions that prevail, or have prevailed therein. It is the object of this paper to discuss, both from the theoretical and practical standpoint, some of the more important phenomena dependent upon this correlation, and their effects upon the agricultural peculiarities of the chief climatic subdivisions.

In order to render this discussion intelligible to the general reader, it will be best to recapitulate, as briefly as may be, the several agencies that contribute toward the process of soil formation from rocks and their decomposition products.

THE PROCESSES OF SOIL-FORMATION.

HOW SOILS ARE FORMED.

(*a*) Mechanical Agencies.—The chief *mechanical* agencies concerned are the following, mentioned in the order in which they usually follow each other in nature:

1. Effects of *changes of temperature*, whereby the several minerals of which many rocks are composed are differently affected, so that their close adhesion is gradually weakened, and minute cracks are formed, which give access to water and air, and to the small rootlets of plants.

*Partial and revised reprint of bulletin No. 3 of the Meteorological Bureau, Department of Agriculture, 1892.

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2. Effects of *freezing water*, which widen still farther the minute crevices by its irresistible expansion, and in case of the larger cracks rends rock-masses into fragments, thus increasing the surfaces exposed and facilitating the removal of the rock from its original site, whether by gravity, moving water, or wind.

3. Effects of *moving or flowing ice* (glaciers). While at present confined to relatively limited areas, yet the powerful action of glaciers in grinding rocks to fine powder, from which soils form with great rapidity, renders this agency of great importance, even at the present time; while in the past, the enormous areas known to have been glaciated are covered largely with soils produced by this process conjointly with that of the water resulting from the melting of the ice. The rocks carried on the surface of glaciers are subject in the highest degree to the effects of changes of temperature, becoming intensely heated during clear days by the sun's rays when unaffected by the denser portions of the atmosphere, and at night again subjected to frost. These frequent and violent changes assist greatly the merely mechanical grinding and abrading process resulting from the ice-movement, both on the surface, within the ice-mass (in the "crevasses"), and on the lower surface, which in the course of time becomes lined with stones that score the rocky bed with deep furrows. Hence, glacier streams are always notable for the large proportion of very fine rock-powder carried by them.

4. The effects of *flowing water* are doubtless at this time the most potent agencies of soil-formation. Apart from the mere removal of loose materials from one point to another, its effects in carrying sand, gravel, and bowlders, according to velocity and volume, are prodigious. For these rock fragments not only score the bed of the stream or rill, but by their mutual attrition and abrasion produce more or less of fine powder similar to that produced by glacier action, but usually much more mixed in its ingredients, because derived from a wider range of surface. "Alluvial" soils thus formed are usually the most generalized in composition, while the "colluvial" soils of rolling uplands and slopes generally are commonly, like those derived from glaciers, more of a localized character.

5. Finally the effects of the *wind* have to be considered. To this agency very extended effects are ascribed by some which by others are attributed chiefly to aqueous action. There can be hardly any doubt about wind and wind deposits in soil-formation; for in many cases no other imaginable agency could have produced the effects observed. Such Æolian soils may either have been carried off by the wind, directly from the weatherward rock, or else soils ready formed may be taken up by the wind and carried sometimes to great distances before being deposited. The sandstorms of the arid region are a case in point. In desert regions the distinction between the regions of coarse gravel ("Hammada" of the Arabs) stands in pointed contrast to the region of shifting sand; while farthest under the wind, we find dust deposits of extreme fertility. The dunes of the sea-coast belong, of course, to the same category.

(*b*) Chemical Agencies.—The *chemical* processes that contribute essentially to the formation of soils are these:

1. *Solution by water alone.* Since few substances known, and especially few of those forming rocks, are entirely insoluble, even in pure water, while some (like gypsum) are easily dissolved in the latter—even rain

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water carries these effects with it wherever it falls. But, practically, no pure water is found in nature, and it has required the utmost refinements of apparatus and manipulation to obtain it even artificially. The impurity which it almost invariably carries is an apparently weak, but, in its ultimate effects, very powerful agent, viz.:

2. *Carbonic acid*, the acid of "soda-water," produced naturally by all processes of decay, fermentation, and slow or rapid combustion of vegetable and animal substances, coal, etc., as well as by the breathing of animals. Being contained in the air, this acid gas is absorbed in rain water, and imparts to it additional solvent properties; being continually generated in the soil by the decay of the vegetable matter, it renders the soil water a relatively strong, acid solvent, which acts steadily upon the mineral matters of the soil and decomposes them still further, rendering their ingredients available for the nutrition of plants.

3. The *oxygen of the atmosphere* is active not only as taking part in the formation of carbonic acid, but also directly in its action upon certain ingredients of rock minerals, notably the iron compounds. Most green and black minerals contain iron in a form (protoxide) which is capable of taking up more oxygen when opportunity is afforded. This occurs when carbonic acid water acts on the minerals containing the iron; the latter is then often completely eliminated in the form of "rust" (ferric hydrate), causing the minerals and rocks to change their color from green or black to yellow or reddish, and by the increase of bulk softening or pulverizing the rock; while, at the same time, the carbonic acid dissolves and carries off, in water solution, a large proportion of the other ingredients.

4. In some cases, *water* enters directly into combination with the substances present or newly formed; thus increasing the bulk of the mass and forcibly rending the original structure. This happens in the formation of clay from feldspar, of gypsum from the mineral anhydrite, in the changing of black "ferrous" minerals into rusty brown, and in numerous other cases.

Weathering and Fallowing.—Thus the combined chemical action of water, carbonic acid, and oxygen, facilitated by the mechanical pulverization of the rocks, is most potent and constantly active in disintegrating both rocks and soils. Aside from the purely mechanical action of flowing water and ice, the effects of all the above agencies are commonly comprehended under the term "weathering," and in agricultural practice, "fallowing."

CLASSIFICATION OF SOILS.

According to the predominance of the several agencies enumerated, the soils resulting from their action may be classified into three chief divisions, viz.:

1. Sedentary or Residual Soils, or soils in place; which result from the quiet action of changes of temperature, frost, etc., in pulverizing the parent rock, together with the solvent action of water charged with carbonic acid and oxygen, but without any removal from the site of the original rock.

2. Transported Soils, which have been more or less removed from their original source; prevalently by the action of water, but also by the aid of gravity and winds. They naturally subdivide into two primarily important and universally recognized subdivisions, viz.:

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(*a*) *Colluvial Soils*, consisting of materials that have been transported short distances only and have not undergone any sedimentation or stratification in flowing water of watercourses, and the distribution of which bears no obvious relation to the latter. They may therefore contain debris of all sizes more or less uniformly distributed through their mass; and they form the bulk of upland and slope soils. In the regions covered by glacial drift, their materials may have come from great distances, but still the soil-mass is destitute of any definite structure, such as belongs to

(*b*) *Alluvial* or *Sediment Soils*, which have been deposited in and from flowing water, therefore occupy areas distinctly related to present or former watercourses or lakes, and have a more or less distinct stratified or bedded structure, according to the nature of the depositing current or basin. The alluvial class therefore includes all "bottom" and "second bottom" valley soils, as well as those of ancient or modern lakes and swamps.

It is hardly necessary to say that between these several classes of soils there is every degree of transition, and it is frequently a matter of choice whether a given soil shall be considered as belonging to one or the other class. This is especially true of the older alluvial soils, many of which in the course of time have virtually become upland soils by the subsidence of the water or the rising of the land and its consequent erosion into hills. The Great Plains of the West, and many of the "mesa" lands of the continental interior and Pacific Coast of America, are instances in point, and so are the ancient river terraces ("benches") now lying high above the present flood-plains.

(*c*) *The Æolian or Wind-Drift Soils* form a third class, already referred to above. While in humid climates such formations are confined to the sea-coasts, they assume great importance in the arid regions, in consequence of the extreme dryness of the land surfaces and the loose character of the characteristic soils. Even the surface conformation of extended areas is sometimes thus determined, as *e. g.* in the case of the hog-wallow lands of the Great Valley of California.

PHYSICAL NATURE OF SOILS.

Speaking in the most general terms, all soils may be considered as consisting of more or less finely powdered and decomposed *rock* (sand, silt), *clay*, and *vegetable matter*, changed to greater or less extent toward the condition of humus or vegetable mold. The relative proportions of these three principal physical constituents determine the most general classification of soils, according to their nature; as *sandy* or *light*, *clayey*, *heavy*, and *humous*. Beyond these, the degree of fineness of the rock debris, and their chemical and physical constitution, determines distinctions such as gravelly, silty, loamy, siliceous, calcareous, magnesian, ferruginous, and others of less general application, although locally often of considerable importance.

CLIMATIC FACTORS THAT MODIFY SOILS.

Influence of Temperature on Soil-Formation.—Within the ordinary limits of atmospheric temperatures, all the chemical processes active in soil-formation are intensified by high, and retarded by low temperatures,

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all other conditions being equal. We can artificially imitate, and produce in a short time, by the application of high temperatures, most of the chemical changes that naturally occur in soil-formation.

This being true, we should expect that the soils of tropical regions should, broadly speaking, be more highly decomposed than those of the temperate and frigid zones. While this fact has not been actually verified by the direct comparative chemical examination of corresponding soils from the several regions, owing to the want of uniformity in methods and the fewness of such investigations in tropical countries, yet the incomparable luxuriance of the natural as well as artificial vegetation in the tropics, and the long duration of productiveness* that favors so greatly the proverbial easy-going ways and slothfulness of the population of tropical countries, offers at least presumptive evidence of the practical correctness of this induction. In other words, the fallowing action which in temperate regions takes place with comparative slowness, necessitating the early use of fertilizers on an extensive scale, has been so much more rapid and effective in the hot climates of the equatorial belt as to render available so large a proportion of the soil's intrinsic stores of plant food; so that the need of artificial fertilization is there restricted to those soils of which the parent rocks were exceptionally deficient in the mineral ingredients of special importance to plants, and that ordinarily form the essential material of fertilizers. Quartzose, magnesian, and other soils resulting from the decomposition of "simple" rocks will everywhere be poor in plant food; again, the intense decomposing or fallowing effect of tropical climates may be offset by an equally intense leaching process in consequence of copious rainfall. It is under these conditions the class of soils now designated as *laterite* soils have been formed in the inter-tropical regions and also elsewhere under corresponding influences. They have usually a glaringly red tint, due more generally to very fine diffusion of iron in consequence of repeated reductions and oxidations than to great abundance of iron compounds (*terra roxa* of Brazil), but sometimes to extraordinary percentages of iron. An example of this, apparently, occurs in the Hawaiian Islands, in the highly ferruginous soils resulting from the decomposition of the black (hornblendic) lavas that are so characteristic of the volcanic effusions of that region. The soils formed from these are sometimes so rich in ferric hydrate (iron rust) that they might well serve as iron ores elsewhere; often having from 30 to 40 per cent of that substance. But as these soils are very unretentive, though very productive at first, they are soon exhausted; the abundant rains having apparently deprived them of almost every vestige of lime, and of most of the potash contained in the original rock. To return lime to them would seem to be the first thing needful in restoring their producing powers; and the coral sand of the beaches would offer a cheap source of supply of that substance. A more detailed discussion of some of these points is given farther on.

Influence of Rainfall on Soil-Formation.—Since water is the prominent agent in the process of soil-formation, it follows that the variations in its supply—in other words, the greater or less amount of rainfall—must affect materially that process. In addition, and especially in connec-

*A special case in point is that of the fertile tract of volcanic soils extending between the cities of Guatemala and Antigua, that have been cultivated from the earliest times of settlement. When fresh these lands yielded about 75 bushels of maize. They have now fallen off to 15 to 20 bushels, but it has taken centuries to bring about this change.

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tion with the rainfall, the *temperature* conditions, already referred to, and the *manner of distribution* of rains through the seasons, in connection therewith, are potent factors.

Leaching of the Land.—One of the most obvious results of an abundant rainfall is the leaching-out of the more soluble portions of the rock constituents that have been formed or set free by the process of weathering. The extent to which this leaching occurs depends, of course, largely upon the perviousness of the soil material to water; it is greatest in "leachy" soils, *i. e.*, those in which not only the surface layer, but also the substrata, are so coarsely sandy as to permit a very rapid passage of water in all directions. From this extreme, through sandy and clayey loams to heavy clay soils, there is every gradation of perviousness to almost impermeability. Whatever water falls on the latter class of soils will largely run off from the surface, hence cannot leach out of them what, in the case of "lighter" soils, is carried currently into the country drainage.

Composition of Sea Water.—The usual nature of the substances so leached out is well illustrated in the salts of sea water, which represent the generalized result of countless ages of this leaching process.

Mean Composition of Sea Water (according to Regnault).

Sodium chloride (common salt)	2.700
Potassium chloride	.070
Calcium sulphate (gypsum)	.140
Magnesium sulphate (Epsom salt)	.230
Magnesium chloride (bittern)	.360
Magnesium bromide	.002
Calcium carbonate ("limestone")	.003
Water (and loss in analysis)	96.495
	100.000

The average saline contents of sea water would thus be 3.505 per cent. In twenty-one determinations of the saline contents of the Atlantic Ocean, the percentage ranged from 3.506 to 3.710. Of this mineral residue, common salt constitutes from about 75 to over 80 per cent.

We see that most prominent among the ingredients mentioned here is common salt (sodium chloride), which forms nearly four fifths of the total solid contents. Next in quantity are the compounds of magnesium, viz.: Epsom salt and bittern, with a very small amount of the bromine compound. Next come the compounds of calcium (lime), of which gypsum is the more abundant; while the carbonate, so abundant on the land surface in the various forms of limestone, is present in minute amounts only, yet enough to supply the substance needed for the shells of shell-fish, corals, etc. Least in amount of the metallic elements mentioned is potassium, which, like sodium, exists mainly in combination with chlorine. Calculating the total amounts of the latter substance, we find that it exceeds in weight any other element present in the salts of sea water, being two sevenths of the whole amount.

Substantially the same result, with variations due to local causes, is obtained when we consider the saline ingredients of lakes having no outlet, and in which, therefore, the leachings of the tributary land area have accumulated for ages. The Great Salt Lake of Utah, the land-locked lakes of the Nevada basin, of California, Oregon, and of the deserts of Asia, Africa, and Australia, all tell the same tale; which may be summarized in the statement that the chlorides of sodium and mag-

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nesium, and the sulphates of magnesium and calcium, constitute the bulk of the leachings of the land; while of other substances, potassium alone is present in relatively considerable amount.

While the above analysis shows the ingredients of sea water so far as they can at present be directly determined by chemical analysis, yet the presence of many others is demonstrable, directly or indirectly, from various sources. One is, the mother-waters from the making of sea salt, in which such substances accumulate so as to become ascertainable by chemical means, and even become industrially available in the case of *potash* and *bromine*. Another is the ash of seaweeds, which is indisputably derived from the sea water and contains, among other substances not directly demonstrable in the original water, notable quantities of *iodine* (of which this ash is the commercial source) of *iron*, *manganese*, and *phosphoric acid*. Again, the copper sheathing of vessels, as it is gradually corroded, becomes more or less rich in *silver*, manifestly thrown down from the sea water; and the silver so obtained is associated with minute amounts of *gold*. *Copper*, *lithium*, and *fluorine* have been found in sea water; and it is probable that close search would detect very many of the other chemical elements as ordinary ingredients, in minute amounts. This is what must be expected from the fact that few mineral substances known to us are entirely insoluble even in pure water, and still fewer, in water charged with carbonic acid. The latter is always present in sea water and holds the lime carbonate in solution; on evaporation or boiling, this substance is the first to be precipitated; and thin sheets of limestone from this source are commonly found at the base of rock salt beds, which themselves are evidently the result of the evaporation of segregated bodies of sea water, in the past geological ages.

Summing up the facts concerning the water of the sea and of land-locked lakes with reference to the ingredients of soils needful for the nutrition of plants, it appears that the rock-ingredients leached out in the largest amounts are those of which the smallest quantities only are required by most plants; while of those specially needful for plant nutrition, only potash is removed in practically appreciable amounts by the country drainage.

Insufficient Rainfall.—When, however, the rainfall is, either in total quantity or in its distribution, insufficient to effect this leaching, the substances that otherwise would have passed into the sea are wholly or partially retained in the soil stratum; and when in sufficient amount may become apparent on the surface in the form of efflorescences of "alkali" salts. The presence of the latter is therefore almost always an indication of scanty rainfall, and of other important peculiarities which will be considered more fully hereafter.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE PHYSICAL CHARACTER OF SOILS.

While it is not possible to separate strictly the physical or mechanical from the always more or less concurrent chemical differences caused by climatic influences, some general considerations on the former should precede the discussion of the latter class.

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EFFECTS OF ARID AND HUMID CLIMATES ON THE FORMATION OF CLAY.

One of the most important modifications produced by scantiness of rainfall on soil-formation is the great retardation of the formation of clay from feldspathic rocks (kaolinization) and the sediments derived therefrom. An often-quoted example of this influence is that of the quarries of Syene, in Upper Egypt, where most of the great monoliths employed in the construction of the monuments and temples of Egypt were obtained. In this quarry, which has not been worked for at least two thousand years, the rough blocks that were in progress of quarrying when the work was finally abandoned, are said to show an almost perfectly fresh surface to this day; and a well-preserved surface is also shown by the obelisks and pillars made of the same material and transported to Lower Egypt, where, however, the rainfall is somewhat greater. It is a matter of public note that one of these monuments—"Cleopatra's Needle"—for some time set up in Central Park at New York, is in great danger of destruction from the influence of a totally different climate, in which not only the rainfall but the temperature changes are very much greater than in Egypt. Both factors combined will of course prove even more destructive than one alone would be, for a change of temperature that has resulted in the opening of fine cracks at the joints of the mineral components, if followed by a rain and subsequent freeze, may produce a greater effect in a few days than a thousand years of Egyptian climate would have accomplished. In the case of the obelisk at New York the physical effects just mentioned are doubtless the chief factors of destruction; while the chemical process of kaolinization is too slow to be noticeable at once, although it is clear that it will be enormously accelerated by the breaking up of rock caused by the purely physical agencies.

A similar contrast is found in comparing the granitic rocks of the southern Alleghenies with the corresponding rocks in the arid plateau region west of the Rocky Mountains, as well as in California and Arizona. The sharpness of the ridges of the Sierra Madre, and the roughness of the hard granitic surfaces, contrast strikingly with the rounded ranges formed by the "rotten" granites of the Atlantic slope, where sound, unaltered rock can sometimes not be found at a less depth than forty feet. What is true of granite holds correspondingly, of course, in the case of other rocks.

The inference is that a corresponding difference should manifest itself in the soil formed under the influence of these diverse climatic conditions; and even the most cursory observation shows this to be the case. The result may be best expressed in the general statement, that while the soils of the Atlantic slope are prevalently *loams*, containing considerable clay, and even in the case of alluvial lands oftentimes very clayey or heavy: the character of the soils of the arid regions is predominantly *sandy* or *silty*, with but a small proportion of clay; *unless derived*, directly or indirectly, *from preëxisting formations of clay or clay shales*. Of course the character of these "sedentary" clay soils is substantially independent of climate, their substance having been formed in past geological ages.

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LIGHT SOILS PREDOMINATE IN ARID CLIMATES.

This incoherence of the soil material in arid climates, resulting from the scarcity of clay,* becomes obvious to the traveler in the sand and dust-storms that sometimes annoy him while traversing *e. g.* what has been conventionally known as the "Great American Desert"—a desert only so long as the life-giving influence of water is withheld from it. Droughts may render the surface of the country in the Atlantic States, or in Europe, as dry as the great plains themselves, yet away from highways or cultivated fields little or no dust will ordinarily be raised by the strongest wind, because of the coherence of the soil, which will generally be found covered by a hard-baked crust. In the arid region, under the same conditions, a mere puff of wind may raise a cloud of dust, and a wind-storm becomes almost unavoidably a sand or dust-storm also. "Dust soils," which during the dry season are even in their natural condition so loose as to rise in clouds and render travel very uncomfortable, are not uncommon in Washington and adjacent parts of Oregon, on the uplands bordering the Columbia and Snake Rivers. The mechanical and chemical analyses of three such soils, given in the table below, will convey some idea of their peculiarities in both respects. The same general facts are known of the other arid regions of the globe, whether in Asia, Africa, or Australia.

Dust Soils of Arid Region.

	17	37	79
	Atahnam Prairie, Yakima Co., Wash.	Rattlesnake Creek, Kittitas Co., Wash.	Plateau on Willow Cr., Morrow Co., Oregon.
Chemical Analysis of Fine Earth.			
Insoluble matter	71.67	78.33	79.21
Soluble silica	5.11 } 76.78	2.20 } 80.53	2.30 } 81.51
Potash (K_2O)	1.07	.70	.89
Soda (Na_2O)	.35	.24	.05
Lime (CaO)	2.00	2.08	1.37
Magnesia (MgO)	1.34	1.47	1.08
Br. ox. of manganese (Mn_3O_4)	.04	.07	.06
Peroxide of iron (Fe_2O_3)	6.88	6.13	5.63
Alumina (Al_2O_3)	7.91	6.12	6.02
Phosphoric acid (P_2O_5)	.13	.18	.18
Sulphuric acid (SO_3)	.02	.02	.03
Water and organic matter	2.82	2.35	2.55
Totals	99.33	99.89	99.37
Humus	4.10		.44
Hygroscopic moisture at 15° C	4.98	3.20	4.92
Mechanical Analysis of Fine Earth.			
Clay	.93	3.59	1.27
Sediment of <.25 mm. hydraulic value	30.93	13.06	32.29
Sediment of .25 to .5 mm.	3.20	5.82	12.75
Sediment of .5 to 2.0 mm.	7.18	27.37	37.51
Sediment of 2.0 to 8.0 mm.	21.88	43.78	10.92
Sediment of 8.0 to 64.0 mm.	32.39	4.57	3.97
Totals	96.57	98.18	98.72

*It must be distinctly understood that what is meant here by "clay" is not the mineral kaolinite, but the gelatinous, plastic, "colloidal" substance that results from its physical disintegration, and which alone plays the part of rendering soils coherent.

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Several points of interest that will be discussed in detail further on are illustrated in this table. In their chemical composition the three soils are very good illustrations of generalized soils of the arid region. They also show that the "clay" of physical analysis is not even approximately represented by the "alumina" of the chemical analysis; and that, moreover, the latter substance is not contained in these soils in the form of clay only, since the amount of "soluble silica" is far below that of alumina, while the reverse should be true if they were combined to form clay.

As regards the physical composition, "clay" is shown to be present in very small amounts only; there is a good deal of the finest silt, <0.25 mm.; and then there occurs a conspicuous break in the small amount of sediments just above that point. It may be casually mentioned here that soils of this character are irrigated with difficulty, the water penetrating so slowly that ditches must be run a few feet apart, and the flow continued for a considerable length of time, in order to soak the land.

It will also be noted that the percentages of mineral plant food in these soils are quite large, and that according to all experience they should be found profusely and permanently productive. This forecast is abundantly confirmed by local experience.

"Strong" Soils.—But so generally has the idea of inherent fertility been associated, in the humid regions, with soils of a more or less clayey character, that the terms "strong," "substantial," "durable" are habitually applied to them in contradistinction from "light," "unsubstantial" ones of the sandy or silty type. Hence, the newcomer will frequently be suspicious of the productiveness and durability of soils in the arid region, that experience has proved to be of the highest type in both respects.

The clayey soils that do occur in the arid regions (in California and Spanish America generally known as "adobe"*) owe their existence to one or both of two precedent conditions. Those occupying upland slopes are mostly (though not invariably) directly derived from the disintegration of clay shales that either underlie, or occupy a higher position on the slope; they are therefore either sedentary (soils in place) or colluvial, and derive their clay from that which was formed in former geological ages. The valley adobe lands, on the contrary, are mostly paludal or swamp formations (therefore not formed under "arid" conditions), and represent either the finest materials that remain suspended in slack water, from any source; or sometimes the direct washings of the clayey hill soils, above mentioned. Examples of both kinds are abundant in the Great Valley of California, as well as in the coast ranges of that State.

Great Depth of Soil in Arid Climates.—But it is not only in this point that the physical composition of the soils of arid climates differ from those of humid regions. Another point of great importance is that the difference between soil and subsoil, which is so striking and important in regions of abundant rainfall, is largely obliterated in arid climates. Very commonly hardly a perceptible change of tint or texture is found

* It is to be regretted that in the publications of the U. S. Geological Survey, this name has been erroneously applied to the loam commonly used in the construction of adobe houses. Agriculturally, it means "a heavy clay soil," such as could not be used in building.

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for depths of several feet; and what is more important, material from such depths, when thrown on the surface, oftentimes subserves the agricultural uses of a soil nearly or quite as well as the original surface soil. The unconcern with which irrigators proceed to level or otherwise grade their land, even though this may involve covering up large areas of surface soil with subsoil from several feet depth; the rapidity with which the red loam of the placer mines of the Sierra Nevada foothills is re-covered with the natural forest growth of the region, etc., are examples familiar to the residents but surprising to newcomers, who are accustomed to dread the upturning of the subsoil as likely to deprive them of remunerative crops for several years, until the "raw" subsoil has had time to be "vitalized" by the following effect of the atmosphere, and to acquire the needful amount of humus or vegetable mold.*

The cause of this difference is readily understood when we consider what it is that causes the contrast between soil and subsoil in humid climates. As before stated, soils are there, as rule, richer in clay; this clay, becoming partially diffused in the rain-water whenever a somewhat heavy fall occurs, percolates the soil in that condition and tends to accumulate in the subsoil; the result being that almost without exception, the subsoils of the humid regions are very decidedly more clayey than the corresponding surface soils. It is only in alluvial lands formed by periodic overflows, which bring down deposits of varying nature at different times, that any material departure from this rule is found; more rarely it occurs in the case of colluvial soil overlying sandy beds, but supplied with clayey matter from a higher-lying outcrop.

But not only does this clay water tend to render the subsoil more compact and heavy, making it less pervious to water and air, but it is assisted materially in this by the action, discussed below, which tends to leach the lime carbonate out of the surface soil into the subsoil. The accumulated clay is thus frequently more or less cemented into a "hardpan" by lime, partly in the form of carbonate, partly in that of zeolitic (hydrous silicate) compounds; adding to the compactness of the subsoil, and therefore to the usual specific difference between soil and subsoil, viz.: the deficiency or absence of humus, and the difficulty of penetration by, and aëration of, the roots of plants. This point will be further considered below.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE FORMATION OF HUMUS.

Succeeding more or less closely, in time, the physical and chemical agencies upon which depends the formation of soils from rocks and the continued decomposition of the rock powder in soils themselves, there comes another which is most intimately connected with plant growth, and scarcely second in importance to those already referred to. This is the decay of vegetable matter in the soil and the formation of what, in a comprehensive way, is known as humus or vegetable mold—the dark-colored, sometimes jet-black, remnant of vegetable decomposition under at least partial exclusion of air. While now known not to possess that exclusive importance for vegetable nutrition that was at one time

*In the case of a cellar 7 to 10 feet deep, near Nevada City, Cal., the red soil-mass dug out was spread over part of a vegetable garden close by, and as a venture the annual vegetables—tomatoes, beans, watermelons, etc.—were sown just as usual. They not only did well but better than the portions not covered, which had been cultivated for a number of years and were somewhat exhausted thereby.

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attributed to it, humus is still recognized as one of the most important soil ingredients for the purposes of practical agriculture; and as its formation is directly dependent upon climatic conditions, its variations in accordance with them form essential points of difference between the soils of humid and arid regions.

Vegetable matter exposed to the action of the *air alone* will in the course of time be completely destroyed by the slow process of combustion ("eremacausis") which is unaccompanied by any essential fermentative action, and is materially assisted by an elevated temperature.

When submerged in water it undergoes a very different process, namely, a gradual conversion into a brown mass, of which the extreme result is peat. The coffee-colored waters of peat-bogs prove that this substance, or a portion of it, is soluble in water; and these brown waters are distinctly acid to test-papers and sometimes even to the taste. Hence the popular designation of soils formed or existing under such conditions as "sour," is strictly correct; and it is well known that the correction of such lands by means of drainage, and the neutralization of the acidity in the soil (usually, in practice, by marling), are conditions-precedent of their profitable cultivation.

Peat-bogs, properly so called, can exist only in cold-temperate, humid climates, not only because the peat moss, which forms their chief vegetation, cannot flourish in dry air, but also because the vegetable matter accumulating under water in warm regions undergoes a more rapid fermentation, whereby much of it is converted into gaseous products (carbonic and marsh gas), and the peaty or humus residue is greatly less in amount. But the conditions for the formation of "sour" soils may be realized in any climate, in the presence of water; as in the "tule" or marsh lands of California as well as of Louisiana and Florida, or in the heads of ravines where springs or oozes of water constantly flow. But in the marshy Arctic lowlands or tundras, the low temperature maintained, even during the short summer, renders the progress of humification extremely slow, preventing the formation of true peat even where the peat moss can maintain its existence.

When, on the contrary, vegetable matter decays *underground* in well-drained land, the process of "humification" has a result different from either of the two preceding cases. The humus formed is of a darker and sometimes jet-black tint, and it imparts no color to water percolating through the soil, being completely insoluble. It is this kind of humus that is desired by the farmer everywhere; it is hailed by him as the mark of high productiveness in the case of new lands, and he considers the maintenance of a proper proportion of it in the cultivated land as essential to profitable culture.

It should be noted right here that the brown humus of bogs is not only neutralized in its acidity by lime, but it is also rendered insoluble in water by its action, and in the course of time is transformed into true, black, insoluble humus.

A product intermediate between peat proper and true soil-humus is found forming the surface of the primeval forests of the coast region of northwestern America, from middle Oregon to Alaska. It is known to the inhabitants as "duff," probably from its resemblance to the holiday pudding of seafaring men, that is usually colored by molasses or brown sugar. The natural "duff" is the result of the decay, above ground, of the

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countless trunks of fallen trees that so commonly obstruct the passage of any but the most agile pedestrian in those regions, and upon which the new generation of trees frequently finds a most congenial starting point and foothold. In the course of time, in a climate in which daily rains are the rule rather than the exception, these trunks flatten out and in the aggregate form a surface covering occasionally several feet in thickness, on which rank mosses, Linnæa, various pyrolas, Prince's pine, and similar plants flourish in dense masses; while grasses or anything else affording pasturage are conspicuously absent. The brown tint of the surface layers of the "duff" gradually deepens as the depth increases, and finally there is an insensible transition into normal, black soil.

Influence of Aridity upon the Formation of Humus.

It is easily seen that under the influence of hot, rainless summers, the process first mentioned above, viz., eremacausis or slow combustion, which leaves little residue beyond the mineral ash of the vegetable matter, must prevail very largely; and that, exceptional circumstances apart, the pervious soils of the arid regions are likely to contain less humus than those of humid climates. Broadly speaking, actual examination amply proves this presumption to be correct; and among the agricultural practices which prove very successful in the eastern United States, but largely fail west of the 100th meridian, is one bearing on this very point. Straw, or strawy manure, cannot be profitably plowed in, in its raw condition, in the arid regions, because of its failure to decay and to become a portion of the soil within any reasonable limit of time. Hence, these precious materials were, during the earlier years of California agriculture, most commonly burnt to get them out of the way, so as not to interfere with the success of crops by keeping the soil too open, thus preventing the germination and rooting of the grain. The rapid burning of the straw really did little more than to accomplish in a short time what in the course of nature would have taken two or three years, by the agency of slow eremacausis; ordinarily it was only through the winter months that any material amount of humification could take place, under the influence of moisture and an only moderately low temperature.

Climatic conditions thus compel the farmer of the arid region to "cure" his straw or manure *before* using them on the field; unless, indeed, he can so far control the climate by the command of irrigation water as to restore, substantially, the humid conditions necessary for the rapid fermentation of manure in the soil itself, and for the humification of dry straw or refuse. The extra labor thus involved is a material drawback to free utilization of stable-yard manure, and of all dry vegetable refuse of the farm; and there thus arises a natural inclination toward the use of the easily applicable commercial fertilizers, whenever fertilization becomes necessary. That the openness of most of the soils and the high summer temperature must in a measure modify the selection, and even the mode of application of these, is obvious. To be effective and utilized to the best advantage, they must be put in to a greater depth than would be required where the surface soil is not liable to become air-dry, and perhaps quite hot, during the summer days; for otherwise the roots would be induced, in following the direction of greatest food supply, to come within dangerous proximity to the arid surface.

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These considerations apply mainly, of course, to the characteristic soils of the arid climates—the silty and sandy ones—which are the result of a *general* process, and not of the disintegration, in place, of clayey beds or clay shales, or of slow deposition in river or littoral swamps. For in these the atmospheric influences are so far limited by their closeness, as well as by their tenacious retention of moisture, that the process of humification can proceed under much more favorable conditions; and hence we find among this class of soils ("black adobe") very much larger humus percentages, approaching nearly to those of the soils of the Mississippi Valley.

Few of the characteristic upland soils of the arid region contain over 0.40 per cent of true humus;* the mesa (fruit-growing) soils of South California mostly fall below one fourth of 1 per cent (0.25 per cent). In the humid region of the Cotton States, three fourths of 1 per cent is a common amount, and few even of the "pine-woods" soils fall below one half per cent (0.50 per cent). This difference is important because the humus of the soil is the repository of that highly important soil-ingredient, nitrogen, the replacement of which is the most costly of all where clovers cannot be used for green-manuring.

From this statement it might be inferred that the soils of the arid region are, on the whole, deficient in nitrogen, and would soon need its artificial replacement if drawn upon by cultivation. Acting upon this presumption, it has been usual to prescribe the use of nitrogenous fertilizers as one of the first needs of such soils when production began to decrease.

Actual investigation has, however, shown that this presumption is not well grounded. Comparative determinations of the nitrogen contents of the humus (*matiére noire*) of the humid and arid soils, respectively, have shown that in the latter the nitrogen percentage is materially higher than in that of the humid region, in consequence, apparently, of a process of accumulation resulting from the more rapid eremacausis of the nitrogen-free portions of plants. It is reasonably presumable that the humus so rich in nitrogen will lend itself more readily to the process of nitrification which must precede the assimilation of the soil nitrogen; a conclusion corroborated by the well-known abundant occurrence of nitrates in the soils of arid regions. Thus, probably, on the average not only is the aggregate supply of nitrogen in the soils of the arid region approximately equal to that of humid soils, but its absorption by plants is exceptionally favored by the climatic conditions.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE CHEMICAL PROCESSES IN AND CHEMICAL NATURE OF SOILS.

Owing to their intimate interdependence, the chemical processes that are constantly active in soils have to some extent been mentioned already in connection with the discussion of the physical characters. They will now be considered more in detail, in their connection with climatic conditions.

The Leaching Process.—One material difference caused by a copious rainfall as compared with a scanty one, has been mentioned in the

* That is, "matiére noire" as determined according to Grandeau's process of extraction; the only method by which unhumified organic débris can with certainty be excluded from the determination. Both combustion, and extraction with alkaline lye, yield results of no value, varying widely with the season, in one and the same soil.

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current leaching-out of the easily-soluble alkali salts; notably those of sodium, and to some extent, of potassium also, together with certain easily-soluble earthy compounds (sulphates and chlorides of calcium and magnesium) and occasionally of other locally abundant soluble substances. These salts being carried through the soil into the country drainage, gradually accumulate in the basins finally receiving the same, whether oceans or inland lakes.

In arid regions these salts are, on the contrary, retained in the soil to a greater or less extent; they tend naturally to accumulate in the lower ground, toward which they are carried by the occasional heavier rainfalls, as well as by the general seepage.

Before considering in detail the effects of this retention of the salts commonly known to be soluble, it is necessary to discuss the effects of climate upon another substance, viz., lime carbonate, commonly presented to us in the form of limestone and chalk.

Lime Carbonate is Soluble.—Although ordinarily considered insoluble in water, when in the form of marble, limestone, or chalk, lime carbonate is yet sufficiently soluble in the soil water—always more or less charged with carbonic acid—to be materially affected by the leaching process. While much less soluble than the salts of potassium, sodium, or magnesium, and also less than gypsum or lime sulphate, yet the constant tendency is *to leach it out of the surface soil into the subsoil*, and *from the soils of the uplands into those of the lowlands*. We shall therefore expect to find, ordinarily, each subsoil a little richer in lime carbonate than its surface soil; and the valley soils more calcareous than those of the adjacent uplands. A comparison of series of such analyses clearly demonstrates the overwhelming prevalence of this difference, so far as the contents of easily soluble lime is concerned; but owing to the fact that the surface soil is more fully exposed to atmospheric influence than the subsoil, the former may at times be found to contain more actual *carbonate* than the subsoil (where it often suffers transformation into other compounds). Such a time is at the end of the dry season, during which (as Storer has first shown) lime carbonate is formed from other compounds of lime; a highly important part of the "fallowing" process. But during the following rainy or winter season the carbonate is again washed into the subsoil, so that in humid climates it may in spring be almost absent from the surface soil itself.

But this being so, it follows that in arid climates, in which the rainfall is insufficient to leach the soil even of its very easily soluble alkali salts, the lime carbonate must of necessity accumulate to even a greater extent than the former. We should therefore expect to find the soils of the region west of the 100th meridian in the United States, and generally those of arid regions everywhere, richer in lime than those of the humid regions, and particularly of those having abundant and frequent rains during a warm summer. For under the latter conditions, the fermentation and oxidation of vegetable matter in the soil is very active, generating a large amount of carbonic acid, which is taken up by the soil water and readily dissolves lime carbonate; and the rainfall being sufficiently copious, this solution is carried through porous soils and subsoils into the country drainage.

Striking exemplifications of this action are sometimes seen in the case of lands either naturally very calcareous or made so by marling, and underdrained by tile. After a number of years not only will the tile

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be found incrusted more or less with lime carbonate in the form of "sinter" or tufa, but sometimes, where the flow is habitually somewhat arrested, the accumulation may become so great as to seriously obstruct small tiles, which is therefore inadvisable to use in such soils. The principle involved here is precisely the same as that upon which depends the formation of stalactites in limestone caves, as well as that of the latter themselves.

We shall thus expect to find the upland soils in the regions of summer rains relatively poor in lime, unless indeed they are underlaid more or less directly by, or derived from, some geological formation rich in that substance, from which the supply is kept up. Such is the case in the "residual" soils of the "prairies" of the Mississippi Valley; and generally in limestone regions. And since lime is an exceedingly important soil ingredient, conditioning very materially the thriftiness of soils, it has in the humid regions become a common adage that "a limestone country is a rich country." This is true at least wherever the limestones are not very pure, as is mostly the case in North America; while in the portions of Europe in which chalk—an exceedingly pure limestone—is the country rock, "poor chalk land" is frequently spoken of.

But in the arid regions no such distinction is popularly made. This is natural since, as we have seen, lime carbonate is constantly accumulating in their soils, and therefore it is not to be expected that the connection with a limestone formation should make any material difference in their quality.

This leaching process is of such great importance, both theoretically and practically, as influencing the thriftiness of soils, and therefore the agricultural practice of the humid and arid regions respectively, that a somewhat detailed presentation and discussion of the facts is called for; the more as these have never, as far as I am aware, been definitely observed or placed on record heretofore.

For the study of this question an extended comparison of the composition of the soils of representative arid and humid regions is required; and I have for this purpose gathered together and tabulated for comparison, all the available analyses of soils from the humid and arid portions of the United States, respectively.

COMPARISON OF SOILS FROM THE ARID AND HUMID REGIONS OF THE UNITED STATES.

To give in detail the large number of analyses upon which the following table is based, would exceed the proper limits of this paper. As the greater portion of them are in print in publications not difficult of access, references are given to the records from which the data have been derived; only as regards the soils of Washington and Montana, the data are still in manuscript only, and form part of the records remaining in the writer's hands since the regrettable cessation of the Northern Transcontinental Survey, prosecuted from 1880 to 1883 under the auspices of the Northern Pacific Railroad.

Selection of Data for Comparison—Methods of Analysis.—As it is absolutely essential that in making such comparisons the analyses used should have been made by exactly the same methods, I have included in it exclusively those for which this condition is with certainty fulfilled, namely, the several series made under my own direction, from

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1857 to the present time, and those made in connection with the Geological Surveys of Kentucky and Arkansas (first under the direction of Dr. David Dale Owen, and since his death under that of others), mostly by Dr. Robert Peter, the veteran chemist of the Kentucky Survey at this time. Some of which the comparability in this respect is probable but not certain, published in the reports of other States, have been omitted because of this uncertainty.

Soils from Calcareous Areas Omitted.—Another consideration has governed the omission of a large number of soils that have been analyzed on the same plan, from the present comparison. It is plain that if we were to include such as have, in their origin, a more or less direct connection with calcareous formations, either as residuals still underlaid by such formations, or as alluvials and colluvials derived from the same, the climatic influences would be obscured and the comparison still further vitiated by the accident of the numerical proportion between the number of such soils, and those derived from non-calcareous materials, that happened to have been chosen for examination. *Tennessee* forms a case in point: it happens that all of the seventeen soil analyses made for that State during the census work of 1880 are more or less directly connected with calcareous formations which underlie the prominent agricultural subdivisions thus far studied. From this cause Tennessee is unrepresented in the list of States below: and for the same reason a very large proportion of Dr. Peter's analyses of *Kentucky* soils are thrown out, *e. g.* the well-known "blue grass region," and generally that portion of the State covered by limestone formations.

On the same ground, of 141 analyses of *Arkansas* soils by D. D. Owen and Dr. Peter, only 38 could be admitted to comparison. In this case, as in that of Mississippi and Louisiana, the large proportion of "bottom soils" derived directly from the calcareous clays of the Port Hudson beds and from the Loess area, has necessitated the body of the exclusions.

In *Mississippi*, the soils of the cretaceous and tertiary prairies, of the Loess proper, and the heavy soils of the alluvial area (Yazoo bottom) that are directly derived from the Port Hudson clays, are excluded: but not those of the recent alluvium, nor those of the tributaries from the uplands. Thus, out of 130 analyses, 33 have been excluded. The analyses of the brown loams overlying the Loess, though somewhat influenced by the subjacent formation, are nevertheless retained.

Of 25 available analyses of *Louisiana* soils, 7 are excluded because of their direct connection with the Port Hudson and Loess materials.

Of 40 available analyses of *Texas* soils, all but 7 are from "prairie" areas known to be underlaid by calcareous materials. The 7 forming the somewhat doubtful exception (because in part from areas underlaid by calcareous tertiaries) are from points lying both in the humid and arid portions of the State, and therefore would not make a fair showing for either. The same is true of the few analyses of soils from *Indian Territory*.

Of 56 available analyses of *Alabama* soils, all but 6, representing the well-known "prairie" areas, enter into the averages.

All known analyses of *Florida* soils, 7 in number, are included.

Of 60 analyses of *Georgia* soils, 17, representing the essentially calcareous areas of what is known as "Northwest Georgia"—palæozoic

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terranes—are excluded from the comparison, together with three others from the tertiary region.

All available soil analyses from *South Carolina* are included. So also are those from *North Carolina*, except those made for the geological survey of the State, the method used in these analyses being unknown, and apparently different from that adopted in the census work of 1880.

The same general system of selection and exclusion has, of course, been put in force on the available soil analyses from the arid regions; represented, thus far, by *California*, *Washington*, and central *Montana*. As is well known to geologists, these are regions very deficient in limestone formations, so that it is difficult to obtain material for a home supply of lime for building and other purposes. It is true that the rock material of the cretaceous and tertiary beds covering large portions of these regions are often more or less calcareous, and would, by disintegration, yield a slightly calcareous average material. But the same is true of a large portion of the humid region on areas which nevertheless have not been ruled out from this comparison. Wherever it is known that a specially calcareous deposit is near at hand, and may have contributed an extra proportion of calcic carbonate, the analysis has been ruled out; and on the same ground as in the case of the soils of the Lower Mississippi, where the old swamp (Port Hudson) beds have been an essential contributory factor, the corresponding soils from the troughs of the valley of California have been excluded. Thus of a total of 236 analyses of *California* soils, 38 have been excluded from the averages.

Out of 80 analyses of *Washington* soils, 4 showing unusual proportions of lime were ruled out on suspicion that there might be a special source of lime involved. In the rest, the range is so steadily from a little below one to a little over two per cent, that there was no basis for a discrimination, the more as the country is destitute of limestones, and save, at a few points, even of any obviously marly formations.

In the case of *Montana*, 14 out of 43 soils have been ruled out, mostly on suspicion of, but partly because of known connection with limestone formations; as *e. g.* in the case of lands at the foot of the Big Snowies, a limestone range forming part of the northern rim of the Judith Basin.

The rule thus having been applied, as impartially as possible, to the soils of both humid and arid regions, I believe that the conclusions flowing from a discussion of the results of the comparison is entitled to as much weight as are those of any comparison based on large numbers of observations made, not with reference to the special point under consideration, but with a practical object of which the governing conditions were more or less uncertain and required to be ascertained by a process of elimination.

The table gives, first, the averages for each ingredient for each of the States represented; the number of analyses from which the averages are derived being given in each case. These averages are given separately for the States of the humid and arid regions, respectively; and at the base of each group the grand average is shown in two forms. The first gives the figures as derived from *the aggregate number of soil analyses in each great group*, being 466 for the humid and 313 for the arid, divided into the totals resulting from the summation of each ingredient for the whole 466.

The second form is that in which *the soils of each State are considered as representative* of the general character of such State, as the result of

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intentional selection; such as actually occurred in the cases of those included in the census work of 1880. The figures given here are therefore the result of a *summation of the State averages* as such, and of their division by the number of States represented.

It may be cursorily noted here that while these two modes of presentation do change the figures a little, yet in either form the same general result is outlined with striking accuracy. It will be noted that in some cases the averages for States are not all based upon the same number of analyses. This happens mostly because of omissions made in determinations, occurring most frequently in the case of the item "soluble silica." It must be understood that in the earlier work the importance of ascertaining this point in every case had not been thought of. Hence it is entirely wanting in the analyses representing Kentucky and Arkansas, and in all the earlier work relating to Mississippi. This explains why in some cases the averages of the first two columns ("insoluble residue" and "soluble silica") do not sum up correctly in the third column, which, where both determinations have been made, should be the sum of the preceding.

To amplify the evidence as much as possible there are also given six analyses from *Colorado*, *New Mexico*, and *Utah*, made for the purpose of ascertaining the probable success of sugar beets, and therefore, as it happens, representing characteristic "mesa" or plateau lands. These analyses were made in the laboratory of the California Experiment Station by Mr. H. P. Dyer, chemist to the Utah Beet Sugary, near Lehi.

The nine analyses from *Wyoming*, made at the Experiment Station at Laramie, while perhaps not strictly comparable because of a somewhat different method of preparing the soil-solution (Kedzie's), are evidently in line with the rest from the arid region.

References to Sources of Data.

For the analyses of soils from the States of North and South Carolina, Georgia, Florida, and Alabama, Report of U. S. Census for 1880, vol. 6.

For the States of Mississippi, Louisiana, and Arkansas, *ibid.*, vol. 5; from the reports of the respective geological surveys and reconnoissances, and partly from manuscript records still unpublished.

For Kentucky, the reports of the Geological Survey of Kentucky from 185– to the present time; analyses by Dr. Robert Peter.

For California, the several reports of the College of Agriculture and Experiment Station of the University of California, from 1877 to the present time.

For Washington and Montana, the manuscript records of the Northern Transcontinental Survey, from 1880 to 1883.

For Utah, New Mexico, and Colorado, manuscript record of work by H. P. Dyer, Chemist to the Utah Sugar Company, Lehi, U. T.

For Wyoming, Bulletin No. 6 of the Wyoming Experiment Station, May, 1892.

The data concerning humus are derived from investigations made at the California Station. See "Agricultural Science," April, 1894.

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Average Composition of Soils in the Humid and Arid Regions of the United States.

Name of State.	No. of Soils Averaged.	Insoluble Residue.	Soluble Silica.	Total Insoluble Residue and Soluble Silica.	Potash.	Soda.	Lime.	Magnesia.	Brown Oxid Manganese.	Peroxid of Iron.	Alumina.	Phosphoric Acid.	Sulphuric Acid.	Water and Organic Matter.	Total.	Hygroscopic Moisture.	Temperature of Absorption, C.	Soluble Phosphoric Acid.	Carbonic Acid.	Humus Per Cent in Soil†.	Nitrogen Per Cent in Humus†	Nitrogen Per Cent in Soil†
North Carolina	20	81.627	3.505	85.133	.145	.057	.088	.080	.071	4.718	5.713	.118	.061	3.977	100.168	4.282	21.1	....	.....			
South Carolina	11	83.493	3.425	86.919	.123	.059	.114	.154	.083	2.771	5.700	.097	.108	3.899	100.039	4.228	23.6	....	.....			
Georgia	40	86.066	2.887	88.954	.150	.065	.076	.099	.090	2.751	4.018	.111	.096	3.619	100.029	3.541	17.0	....	.....			
Florida	7	94.277	1.172	95.449	.101	.034	.091	.027	.077	.749	1.169	.091	.069	2.274	100.136	2.204	24.4	....	.....			
Alabama	50	81.576	4.893	86.469	.231	.073	.169	.210	.120	3.814	2.699	.134	.053	4.039	100.011	7.066	20.2	....	.....	1.50	5.2	.132
Mississippi	97	85.870	4.391	89.714	.276	.109	.145	.312	.137	2.643	4.069	.091	.029	3.331	100.176	5.410	15.4	....	.....			
Arkansas	38	.....	.....	88.539	.165	.056	.081	.430	.205	3.099	3.511	.150	.045	3.704	99.931	2.473	.....	....	.....			
Kentucky	185	.....	.....	86.719	.199	.104	.081	.193	.197	6.008	3.523	.109	.038	3.691	100.862	1.845	.....	....	.....			
Louisiana	18	78.393	6.837	85.231	.290	.086	.163	.379	.153	4.543	5.667	.129	.067	3.480	100.261	6.656	24.5	....	.....			
Total for humid region	466	84.031	4.212	87.687	.216	.091	.108	.225	.133	3.131	4.296	.113	.052	3.644	100.178	4.650	18.5	....	.....	.....	.....	....
Averages by States	.....	84.472	3.873	88.126	.187	.071	.112	.209	.126	3.455	4.008	.114	.065	3.557	100.093	4.189	20.9	....	.....	.....	.....	....
California	198	67.882	8.960	76.842	.644	.277	1.075	1.488	.062	6.303	8.721	.083	.048	4.396	100.048	5.925	.....	.03	1.148	.75	15.87	.101
Washington	76	75.021	3.673	78.696	.777	.249	1.378	1.171	.049	5.530	6.063	.173	.028	5.226	99.952	5.941	.....	....	.403	.....	.....	....
Montana	39	66.141	6.235	72.376	1.005	.226	2.483	1.494	.057	4.459	7.145	.178	.029	7.133	99.935	8.712	.....	....	2.398	.....	.....	....
Total for arid region	313	70.565	7.266	76.135	.729	.264	1.362	1.411	.059	5.752	7.888	.117	.041	4.945	99.993	6.281	.....	....	1.316	.....	.....	....
Averages by States	.....	69.681	6.289	75.652	.825	.251	1.645	1.384	.056	5.431	7.309	.144	.035	5.585	99.978	6.859	.....	....	1.316	.....	.....	....
Utah	4	74.40	7.50	81.90	.840	.320	1.590	.960	.030	6.410	3.150	.192	.031	4.140	99.563	.....	.....	....	.....	.....	.....	....
New Mexico	1	63.20	7.32	70.52	.732	.176	*10.060	1.007	.020	4.031	2.560	.103	.062	3.197	99.849	CO_2 7.360	.....	....	.....	.....	.....	....
Colorado	1	69.61	11.12	80.73	.964	.113	.706	.845	.006	6.640	5.560	.090	.033	4.430	100.117	.....	.....	....	.....	.....	.....	....
Average of the six	.....	68.74	8.65	77.72	.845	.203	.882	.937	.010	5.670	3.757	.128	.049	3.922	99.843	.....	.....	....	.....	.....	.....	....
Wyoming	9	75.79	2.45	78.24	.720	.470	2.670	1.450	.....	3.320	5.850	.180	.100	4.790	99.690	.....	.....	....	1.90	.....	.....	....

*Omitted in the average. †Approximate averages from limited data.

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LIME CONTENTS OF SOILS IN THE ARID AND HUMID REGIONS.

Considering in this table, first, the ingredient under discussion above, viz.: *lime*, a glance at the column for the two regions shows a surprising and evidently intrinsic and material difference; approximating, in the average by totals, to the proportion of 1 to 12; in the average by States, 1 to 14½. This difference is so great that no accidental errors in the selection or analysis of the soils can, to any material degree, weaken the overwhelming proof of the correctness of the inference drawn upon theoretical grounds, that the soils of the arid regions must be richer in lime than those of the humid countries. For the differences in derivation would, in view of the prevalence of limestone formations in the humid regions concerned, produce exactly the reverse condition of things from that which is actually found to exist; and if further proof were needed, it can readily be found in the detailed discussion of the analyses of the soils of the arid areas forming the contrast. This shows that, for instance, in Washington highly calcareous soils are directly derived from the black basaltic rocks; while similarly calcareous lands are found, in California, to be the outcome of the decomposition of granites, diorites, and lavas.

It is not easy to overrate the importance of this feature of the soils of the arid region, as it is intimately connected with other theoretically and practically important facts which will be discussed later.

Now if it be true that "a limestone country is a rich country" in the humid regions, and if, as the tables show, the soils of the arid regions are *all* calcareous to the extent to which that property serves its general purpose,* then it must also be true that when the deficiency of rainfall in the arid regions is supplied by irrigation, the soils of the arid regions should be exceptionally productive as compared with those of the regions of summer rains.

I think experience shows that this is strictly true, and that in the arid region "poor" soils are very much less common than in the humid climates. As farmers would express it, the land is "*all marled*" in its natural condition; and a smaller area can there, on the average, be made to sustain a family.

Is there not here a clew to the fact that has excited the surprise of many, viz.: that arid or irrigation countries have in the past times been the chosen abodes of dense populations, whether about the rock-hewn cities of Syria, or in those of Arizona? Is it not true that the desert is a desert merely in appearance, and that the life-giving water, brought by the hand of man, is all that is needed to convert it into a land where milk and honey flows?

Upland and Lowland Vegetation in the Arid and Humid Regions.

In the *humid regions* there is always a marked difference between the vegetation of uplands and lowlands, arising not merely from the difference in moisture supply, but evidently of a specific nature. When we

*The lime-percentage usually mentioned in text-books as necessary to the "calcareous" character of a soil ("vigorous effervescence with acids"), implying not less than 4 per cent of the carbonate, is very much greater than is actually necessary to impart all the desirable and characteristic agricultural and vegetative features to soils that depend upon the action of lime. Very much less is, moreover, required for that purpose in sandy soils than in those which contain much clay. (See Report of Tenth Census, Vol. 5, page 64.) The important point is that an excess of lime carbonate must always be present, over and above the lime occurring in combination with other acids.

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discuss the characteristic plants in detail, it becomes obvious that it is *lime* vegetation that forms the characteristic difference in most cases; and by way of counter-proof we find that when the uplands are *themselves* of a calcareous nature, a part of the valley flora ascends into them. To mention one of many instances: The tulip tree (liriodendron, whitewood) is a lowland tree over the greater part of its area of occurrence; but in the Loess or Cane Hills area of the Southwest, as well as in the cretaceous (limestone) hill country of Mississippi, it is conspicuous in the uplands. The same is true of the black walnut, the linden, and many other trees and shrubs characteristic of limy soils.

In the *arid region*, on the contrary, the main difference observable in upland and lowland vegetation (outside of mountain influences) is entirely referrible to moisture conditions; the proof being that so soon as the uplands are irrigated the lowland flora, so far as it is distinct, takes possession. This uniformity of upland and lowland vegetation is particularly conspicuous in the comparatively restricted floras of the Pacific Northwest—Eastern Oregon and Washington, and Montana; where one may travel for days over hill and dale and plains, all equally arid, with scarcely a change in the character of the flora, especially during the dry season. Both uplands and lowlands being nearly equally calcareous, there is no reason for any material difference.

Formation of Calcareous Hardpan in Subsoils.

As stated above, subsoils are in all ordinary cases richer in lime compounds than the overlying surface soil, owing to the solubility of lime carbonate in the soil water, which being followed by air when rain ceases, gradually deposits the lime in the lower layers of the arable stratum, by the well-understood process of aëration. In humid climates, however, the frequent rains, so very variable in amount, rarely allow of the accumulation of very large amounts of this substance at a particular depth. Hence, while in such regions (the prairies of Mississippi and Louisiana) we often find, in soils overlying calcareous strata, a formation of whitish concretions (commonly known as "white gravel") of lime carbonate, yet the formation of continuous layers or sheets of subsoil cemented by lime is not frequent.

In arid regions, on the contrary, the limited rainfall usually penetrates only to a relatively slight depth—a few feet—whence the water afterwards reascends to be dissipated by evaporation. Thus the lime carbonate dissolved in its descent gradually accumulates within a very limited thickness of soil, and chiefly at the lowest point usually reached by it. Concurrently, the diffused clay brought down by each rain stops at or near the same level; and both substances combine to form a mechanical union into a subsoil layer of "hardpan," the cement of which is lime carbonate, and which therefore effervesces ("sizzes") to a greater or less degree when touched with a drop of acid.

These hardpan sheets are usually more or less discontinuous, the areas occupied by them being commonly of a rounded or oblong shape, and lowest in the middle. In case of unusually copious rains, or when irrigated, they may frequently be recognized by the formation of temporary ponds, deepest in the middle or axis of the sheet. Such stagnation of water serves ultimately, of course, to increase the hardness and thickness of the hardpan sheet, by the further dissolution of lime during

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the fermentation of vegetable matter that always occurs in stagnant water, and its subsequent deposition upon the concrete already formed.

Such hardpan areas are familiar to cultivators in the arid regions throughout the world; from the Rocky Mountains to the Pacific Coast, as well as in northwest India, where the "kankar" is a formidable obstacle to the cultivation of lands otherwise very rich and capable of profuse production. It there seems to assume, more frequently than in California and Arizona, the form of a hard crystalline, though very impure limestone, which no tool short of a crowbar can deal with. Of course roots cannot penetrate it, and after irrigation the water stands on the lands underlaid by it, drowning out what might otherwise have been a fair crop. The trouble is experienced to some extent in California, in some portions of the Great Valley, where soils of a fine silty character prevail; less often in the more coarsely sandy lands. In the heavy clay lands ("adobe") of the lower grounds, such accumulations of lime carbonate are also quite common, as might be expected; but, contrary to expectation, they are usually less hard and offer less obstruction to roots and to the penetration of water than is the case in the silt soils. Moreover, the lime hardpan in these clay soils crumbles very rapidly upon exposure to air, or thorough drainage, and is therefore less injurious and less difficult to deal with than in other soils.

MAGNESIA CONTENTS OF SOILS IN THE ARID AND HUMID REGIONS.

While the differences in respect to the proportions of lime are the most prominent and decided, yet the related substance—magnesia—shows also a very marked and constant difference as between the soils of the humid and arid regions. It will be observed that the general average for magnesia in the soils of the Atlantic slope is about double that of lime; Florida being the only State in which the average (of seven analyses) is lower for magnesia than for lime. In the arid region, on the contrary, magnesia on the general average is nearly the same as lime; in the average by States, slightly above it; thus bringing the ratio for the two regions for magnesia up from one to six or seven. This also is so decisive a showing that no accident could bring it about; we must conclude that climatic influences have dealt with magnesia similarly as with lime; which from the standpoint of the chemist is just what might be expected, since magnesia carbonate behaves very much like that of lime toward carbonated waters. It is not, however, known to exert any peculiar influence upon soils or plant nutrition; and hence, while its presence in the soils of the arid region is corroborative of the evidence concerning lime, it is not of similar practical significance.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE "INSOLUBLE RESIDUE."

Remembering, in discussing the facts shown by the table, that the fundamental difference between the *régime* of the humid and arid regions is the presence or absence of an almost continuous leaching process, in which the carbonated water of the soil is the solvent; remembering also that the least soluble portion of rocks and soils is quartz or silica (sand, as usually understood), it would be predicable that this ingredient should in the humid region be found to be more abundant in soils than in the arid. This portion is represented by the "insoluble residue" of the table.

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Inspection shows that both in the averages of the single States, and in both of the general averages, this difference between the soils of the humid and arid regions of the United States is strongly pronounced; the ratio being substantially as 70 per cent in the arid region to 84 per cent in the humid.

We must then conclude that the leaching process must have influenced materially other soil ingredients than lime, which have remained behind in such amounts as to depress the percentage of insoluble residue in the soils. It remains to be shown what are the substances so retained.

"Soluble Silica" and Alumina.—The ingredient most nearly correlated with the "insoluble residue" is the silica which remains behind with it when the acid with which the soil has been treated preparatory to analysis is evaporated to dryness. The gelatinous or pulverulent silica set free by the acid from the soil silicates being thus rendered insoluble in acid and water, it is separated from the *really* insoluble and undecomposed minerals by boiling with a strong solution of sodic carbonate, to which, after boiling, a few drops of strong caustic soda lye has been added in order to prevent the re-precipitation of part of the soluble silica. The amount of the latter is obviously the measure of the extent to which the soil silicates have been decomposed in the treatment with acid.

The most prominent of these is usually supposed to be clay—the hydrous silicate of alumina, that in its purest condition forms kaolinite or porcelain earth. Any alumina found in the usual course of soil analysis is generally referred to this mineral, which contains silica and alumina nearly in the proportion of 46 to 40.

In very many cases, however, the reference of these two ingredients to "clay" is manifestly unjustified. This is clearly so when (as not infrequently happens) the amount of alumina found exceeds that which could form clay with the ascertained percentage of soluble silica; it is almost as certainly so when, in addition to the alumina, other bases (notably potash, lime, and magnesia) are found in proportions which preclude their being in combination with any other acidic compounds present. The only possible inference in such cases is that these bases, together with at least a portion of the alumina, are present in the form of hydrous, and therefore easily decomposable, silicates, or zeolites.

The subjoined analysis of a "clay" obtained in the usual process of mechanical soil analysis (by precipitating with common salt the turbid water remaining after twenty-four hours' subsidence in a column of 200 millimeters), from a very generalized soil of northern Mississippi, shows one of the many cases in which the numerical ratios of the several ingredients are incompatible with the assumption that silica and alumina are present in combination as clay (kaolinite) only:

Insoluble matter	15.96
Soluble silica	33.10
Potash (K_2O)	1.47
Soda (Na_2O)	1.70
Lime (CaO)	.09
Magnesia (MgO)	1.33
Br. ox. of manganese (Mn_3O_4)	.30
Peroxid of iron (Fe_2O_3)	18.76
Alumina (Al_2O_3)	18.19
Phosphoric acid (P_2O_5)	.18
Sulphuric acid (SO_3)	.06
Carbonic acid (CO_2)	None.
Water and organic matter	9.00
Total	100.14

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If in this case we assign all the alumina to silica, as required for the composition of kaolinite or true clay, there remains a trifle over twelve (12.17) per cent of silica to be allotted to the other bases present. Deducting from this the ascertained amount of silica soluble in sodic carbonate, preëxisting in the raw material (0.38 per cent), we come to 11.79 per cent as the amount of silica which must have been in combinations other than kaolinite; viz., hydrous silicates or soil zeolites, formed either with the bases other than alumina shown in the analysis, or more probable, perhaps, containing some of the alumina itself in essential combination.

We are thus enabled to obtain, from the determination of the "soluble silica," an estimate of the extent to which these soil zeolites, that form so important a portion of the soil in being the repositories of the "reserve" of more or less available mineral plant food, are present in the soils of the several regions. A glance at the table shows that the general average of soluble silica is very much greater in the soils of the arid regions than in those of the humid; approximating one to two in favor of the arid division.

But, looking at the details of the several States, however, we find that on the arid side Washington has a relatively low figure for soluble silica; that in the average, however, is overborne by the high figures for California and Montana. The explanation of this fact probably lies in the derivation of the majority of the Washington soils examined, from lake deposits brought down gradually from the humid region at the heads of the Columbia drainage, where sandy beds are very prevalent; while the country rock—the basaltic eruptives—are very basic, and moreover, slow to disintegrate. In California and Montana the rocks are indefinitely varied, and the general outcome of their weathering is plainly a predominance of complex hydrous silicates in the soils, as compared with humid regions.

Zeolites are Repositories of Plant Food.

Nor should this be a matter of surprise when we consider the agencies which are brought to bear upon the soils of the arid regions with so much greater intensity than can be the case where the solutions resulting from the weathering process are continually removed as fast as formed, by the continuous leaching effect of atmospheric waters. In the soils of regions where summer rains are insignificant or wanting, these solutions not only remain, but are concentrated by evaporation to a point that, in the nature of the case, can never be reached in humid climates. Prominent among these soluble ingredients are the silicates and carbonates of the two alkalies, potash and soda. The former, when filtered through a soil containing the carbonates of lime and magnesia, will soon be transformed into complex silicates, in which potash takes precedence of soda, and which, existing in a very finely divided (at the outset in a gelatinous) condition, serve as an ever-ready reservoir to catch and store the lingering alkalies as they are set free from the rocks, whether in the form of soluble silicates or carbonates. The latter have still another important effect: in the concentrated form at least, they themselves are effective in decomposing silicate minerals refractory to milder agencies, such as calcic carbonate solutions; and thus the more decomposed state in which we find the soil minerals of the arid regions is intelligible on that ground alone.

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But it must not be forgotten that lime carbonate, though less effective than the corresponding alkali solutions, nevertheless is known to produce, by long continued action, chemical effects similar to those that are more quickly and energetically brought about by the action of caustic lime. In fact, the agricultural effects of "liming" are only *in degree* different from those produced by "marling" with finely pulverized carbonate; and in nature the same relation is strikingly exemplified in the peculiarly black humus that is characteristic of calcareous soils, but which can be much more quickly formed under the influence of caustic lime on peaty soils. In the analysis of silicates we employ caustic lime for the setting-free of the alkalies, and the formation of easily decomposable silicates, by igniting the mixture; but the carbonate will slowly produce a similar change, both in the laboratory and in the soils in which it is constantly present. This is strikingly seen when we contrast the analyses of calcareous clay soils of the humid regions with the corresponding non-calcareous ones of the same. In the former the proportions of dissolved silica and alumina are almost invariably much greater than in the latter, so far as such comparisons are practicable without assured absolute identity of materials. That is, calcareous clays or clay soils are so sure to yield to the analyst large precipitates of alumina, that experience teaches him to employ smaller amounts for analysis than he would of non-calcareous materials, in order to avoid unmanageably large bulks of aluminic hydrate. It is but rarely that even the heaviest non-calcareous soils yield to the acid usually used in soil analysis more than 10 per cent of alumina; while heavy calcareous clay ("prairie") soils commonly yield between 13 and 20 per cent.* It would be interesting to verify this relation by artificial digestions of one and the same clays with calcic carbonate at high temperature, as it must always be extremely difficult to insure absolute identity of all other conditions in the natural materials.

In most of these cases, what is true of alumina is also true of the soluble silica. But since the latter is constantly liable to be dissolved out by solutions of carbonated alkalies, it is not surprising that this relation is not always shown. What *is* shown in very many cases is that, since the amount of alumina dissolved greatly exceeds that of soluble silica, a portion of the latter must be present in a different form from that of clay (kaolinite); the only choice being between that of complex hydrous silicates (none of which, however, could contain as large a percentage of alumina as clay itself) and *aluminic hydrate*. The latter is alone capable of explaining the presence of more alumina than silica in easily soluble form; and the visible occurrence of "gibbsite" in modern formations renders this a perfectly simple and acceptable explanation. Since this mineral is known to be incapable of crystallization, we are moreover led to the presumption that it will as a rule be found in the finest portions of the soil, viz., in the "clay" of mechanical analysis. What part it may take in modifying the physical properties of the soil, we can thus far only conjecture; in two conspicuous cases of this kind, from Mississippi and California,† the soil material is charac-

* Report of the Tenth Census, vols. 5 and 6; see especially the analyses of soils from Mississippi and Alabama. Also the Reports of the California Experiment Station.

† These cases are Nos. 203 and 207, Mississippi (Rept. 10th Census, vol. 5, p. 256), in which the soluble silica and alumina stand in the ratio of about seven to over twenty; and No. 703, California (*ibid.*, vol. 6, page 712), in which the ratio is as nine to nearly sixteen. See also the table above, page 119.

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terized by such extraordinary tenacity and adhesiveness as to render tillage almost practically impossible, while the natural plant growth is very scanty. No corresponding extreme physical condition is, however, exhibited by the soils from Washington and Oregon, of which analyses are given on page 108, in which an excess of alumina over soluble silica is likewise shown.

There is no very obvious reason, from the chemical standpoint, why *iron*—that is, ferric hydrate or iron rust—should be more abundant in the soils of the arid regions, as the averages given in the table suggest; moreover, the fact does not impress itself upon the eye, since the whitish or grayish tints are by far more common in the arid than in the humid regions of the United States, at least. The California average is considerably influenced by the very highly ferruginous soils from the foothills of the Sierra Nevada; that of Oregon by the black, highly ferruginous country rock from which they are partly derived. The average for Montana is not higher than that of three States of the humid region, and less than that of Kentucky. We might imagine a cause for depletion of the soils of the humid areas of iron, in the frequency with which humid moisture and high temperature will, during the summer, concur toward the bringing about of a reducing process in the soil, which by bringing the iron into proto-carbonate solution would make it liable to be leached into the subsoil, as is frequently the case; yet the resulting "black gravel" or bog ore, in its various forms, is of not infrequent occurrence in the arid regions also. I therefore am not satisfied that a constant difference due to climatic conditions is shown by the data thus far at command.

An unexpected and apparently well-defined contrary relation appears to be shown as regards the related metal, *manganese;* the average percentage of which is in all cases less in the arid than in the humid region, on the average over one to two. The cause of this relation is altogether obscure; it is too well maintained to be accidental; in any case it is, so far as we know, of no consequence to vegetation.

As regards that highly important soil ingredient, *phosphoric acid*, the indication in the table that there is no characteristic difference in the average contents in soils of the arid and humid regions, respectively, is doubtless correct. This substance is so tenaciously retained by *all* soils that there is no conceivable reason why there should be any material influence exerted upon its quantity by leaching, or by any of the differences in the process of weathering that are known to exist between the two climatic regions. Moreover, it is obvious that the average for the arid region is made up out of very widely divergent data; that of California being exceptionally low (lower than any of those for the humid region), while those for Washington and Montana are exceptionally high. The latter is due to country rocks showing abundance of microscopic crystals of apatite, which in some cases raise the contents of soils in phosphoric acid to nearly twice the average given for the States.

The forecast that for most California soils, fertilization with phosphates is of exceptional importance, has already been abundantly confirmed by experience.

The showing made by the table regarding *sulphuric acid*, that sulphates are less abundant in the soils of the arid than of the humid region, is surprising in view of the prevalence of sulphates of the alkalies, which show themselves in the form of efflorescence but too frequently.

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It is true that the majority of such "alkali soils" has, on account of their exceptional and local nature (and usually, heavy lime-contents), been excluded from the comparison; otherwise the showing would have been quite the reverse. No significance attaches, therefore, to these figures.

POTASH AND SODA IN THE SOILS OF THE ARID AND HUMID REGIONS.

The compounds of alkali metals, potassium and sodium, being on the whole much more soluble in water, even without the concurrence of carbonic acid, than those of calcium and magnesium, the leaching process which creates such pronounced differences in the case of the two earths must affect the alkali compounds very materially. Comparison of the soils of the two regions in this respect shows, indeed, very great differences in the average contents of potash and soda. For potash the ratio is 0.216 to 0.725 per cent on the general average, and 0.187 to 0.825 per cent in the average by States; for soda, 0.091 to 0.264 per cent on the general average, and 0.071 to 0.251 per cent in the average by States. For both, therefore, the general average ratio is as 1 to between 3 and 4, for the humid as against the arid region.

It is curious that an approximation to the ratio of 1 to 3, or somewhat less, is maintained in the average proportion of soda to potash in both regions; but this does not by any means hold good in detail, very high potash percentages being often accompanied by figures for soda very much below the above ratio. This is the result of an important difference in the chemical behavior of the two alkalies, which must be considered somewhat in detail in order to obtain a clear conception of the process by which "alkali soils" are formed.

The process of "kaolinization" being that by which clays are formed out of feldspathic minerals and rocks such as granite, syenite, trachyte, etc., results in the simultaneous formation of solutions of carbonates and silicates of potash and soda. These coming in contact with the corresponding compounds of lime and magnesia, also common products of rock decomposition, are partly taken up by the latter, forming complex insoluble, hydrous silicates (zeolites). In these, however, potash whenever present takes precedence of soda; so that when a solution of a potash compound is brought in contact with a zeolite containing much soda, the latter is partially or wholly displaced and, being soluble, tends to be washed away by the rainfall into the country drainage. Hence, potash, fortunately for agriculture, is tenaciously held by soils, while soda accumulates only where the rainfall or drainage is insufficient to effect proper leaching, and in that case manifests itself in the formation of what is popularly known as "alkali soils"; namely, those in which a notable amount of soluble salts exists, and is kept in circulation by the alternation of rainfall and evaporation; the latter causing the salts to accumulate at the surface and to manifest themselves in the form of saline crusts or efflorescences.

The designation of "alkali" soil is, however, popularly bestowed somewhat indiscriminately upon two classes of lands, of very different origin, and requiring for their reclamation quite different treatment. In both cases it is mainly the salts of the alkalies—potash and soda—that imbue the soil and tend to injure vegetation. But when we have to deal with *seashore* lands that owe their saline contents only to the

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more or less continuous flooding with salt or brackish water, the conditions differ materially from those prevailing in the case of the *true* alkali soils, which owe their contents of salts to the scantiness of the rainfall, as heretofore explained.

In the former case, that of *saline* lands, it is chiefly common salt (chlorid of sodium) with some bittern (chlorids and sulphates of calcium and magnesium) that forms the soluble impregnation; which is, of course, practically independent of climatic conditions. In the latter, while common salt is also commonly present, the most abundant is usually Glauber's salt (sulphate of soda), and with it very frequently, as the least welcome ingredient, carbonate of soda (sal soda). According to chemical laws, the presence of the latter substance excludes, practically, the earthy salts classed above as bittern.

The saline shore lands, being practically independent of climatic influences, lie outside of the limits of this paper.

Alkali lands proper are a characteristic feature of *all* regions of scanty rainfall, and are found on all the continents, including Europe, which has predominantly a humid climate. Occasionally we find in the humid regions limited areas to which salts of various kinds are currently supplied from adjacent saline formations, as may be seen at some points in southern Mississippi and northern Louisiana. But such phenomena are entirely local, and do not extend far from the source of supply, because the soluble salts are soon washed into the country drainage by the abundant rains.

In the arid regions, on the contrary, the substances composing the alkali salts are not only retained in their first soluble form, but by their continued presence influence profoundly the processes of soil-formation in several ways.

In the accumulation of alkali salts much of course depends upon the nature of the soil; for it is obvious that in very porous soils the leaching-out can occur much more readily than in those that permit of but very slow percolation, so that a rain may chiefly run off from the surface, and cease before even an approach to a complete downward penetration can have occurred. It is therefore a well-known fact that alkali is most troublesome in the heavier (adobe) lands; and as these are apt, in addition, to coincide with the lower ground, toward which the soluble salts are naturally carried with the seepage, it is not uncommonly found impracticable to cultivate these extremely rich lands without special methods tending either to diminish the alkali itself, or at least to prevent its accumulation at the surface, where its most injurious effects are produced.

It need hardly be said that, special qualities of soil apart, the alkali salts decrease as hills or mountains are approached, where increased slope, and usually pervious soils, combine to permit of their leaching-out with even a relatively scanty rainfall. And inasmuch as ordinarily the rainfall increases rapidly with elevation, everything concurs to prevent the accumulation of alkali in mountainous, or even hilly regions. High-lying plains or plateaus, however, do not by any means necessarily share this exemption; as is well illustrated in the case of the great interior plateaus of America and Asia.

Humus.—The figures of the last three columns of the table give the data thus far available in the comparison of the humus-contents of the soils of the arid and humid regions, respectively, together with the nitro-

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gen percentages contained in the humus substance as stated on page 112. The available data being limited, these figures have to be taken with considerable allowance, especially as regards the average humus-contents of the two classes of soils for which only a very few determinations are available. The figures given for the nitrogen contents, however, may be considered fairly representative and accurate. While it thus appears that, as in the case of potash, the nitrogen percentage in the humus of the two regions approximate to the ratio of 1 to 3, it should be stated that in numerous cases this ratio rises to 1 to 6 and even 1 to 7; the nitrogen percentage in the arid humus reaching as high as 18.66 per cent in one case, thus materially exceeding the nitrogen contents of the albuminoid group, or flesh-forming substances. This is, perhaps, next to the case of lime, the most striking contrast in one of the essential factors of soil fertility in the two regions, and cannot fail to exert a striking influence upon the behavior and consequent treatment of such soil under cultivation. The various bearings and precise character of this influence require much additional study.

THE ALKALI LANDS OF THE ARID REGIONS.

CLIMATIC LIMITATIONS OF ALKALI LANDS.

California.—The question concerning the amount of rainfall under which alkali salts can be retained by the soil to a noticeable and injurious extent can best, perhaps, be investigated in California, where the eastern portion of the great valley constitutes a region of very regularly varied rainfall; ranging from an annual mean of 34.60 inches at Redding on the north, to (usually) less than 6 inches at Bakersfield on the south. The following table shows the decrease of rainfall to the southward for a number of principal points in the valley:

Table of Rainfall on the East Side of the Great Valley of California.

Redding	34.60	Lathrop	11.88
Red Bluff	23.79	Modesto	9.57
Chico	20.91	Merced	10.30
Nicolaus	18.55	Fresno	9.02
Sacramento	19.80	Tulare	7.00
Galt	16.72	Bakersfield	6.08
Stockton	13.18		

Apart from the decrease of rainfall to the southward there is also a diminution from the eastern border of the valley toward the axis, and at some points even to the foot of the Coast Range on the western border. Thus, Chico on the eastern border has nearly 21 inches; Orland, in the same latitude, but on the western edge of the valley, 16 inches; Marysville, on the east, 18.9; Colusa, in the axis, 16.24; Williams, on the west, 13.32 only. Tehama, only ten miles south from Red Bluff, has not quite 16 inches against 23.79 at the former place. Of course, local conditions with respect to prevailing air currents have much to do with such discrepancies, which, however, do not invalidate the general conclusions.

Roughly speaking it may be said that the increase of alkali runs parallel with the decrease of rainfall in the valley; it is at its maximum near the south end, at its minimum near the north end, which in fact it does not reach. So far as its prevalence to an injurious extent is con-

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cerned, it practically ends, east of the Sacramento River, at or near the city of Sacramento, with an average rainfall of nearly 20 inches. Here the proximity to the base of the Sierra foothills exerts a disturbing influence, for we find at Marysville, forty miles farther to northward, but also farther out in the valley, only 18.9 inches of rainfall. Local conditions prevent the accumulation of alkali salts east of the Sacramento River at this latitude; but immediately across on the west side, all the heavier lands are alkaline, and so, with a rainfall of about 16 inches, continue, decreasingly, nearly to the head of the valley near Tehama.

To southward in the San Joaquin Valley, likewise, there is a general increase of alkali in the soil to westward, and in some regions clear to the foot of the Coast Range. The reason is, in part, the scanty drainage from that range, and the fact that the (tertiary) beds forming the immediate slopes are charged with both alkaline and earthy salts, and thus combine to increase the saline contents of the soils independently of climatic conditions; so that even the waters of many streams are in summer undrinkable. From similar causes, limited alkali areas exist locally even near the coast, where the rainfall is in excess of 20 inches.

While, therefore, it cannot be rigorously said that a certain rainfall conditions in all cases the alkalinity or non-alkalinity of soils, it certainly appears that in California at least, 20 inches of rainfall is the upper limit beyond which the retention of any considerable amount of soluble salts in the soil becomes impossible under ordinary conditions of soil and drainage; while below that limit, the degree of alkalinity is dependent more or less upon local conditions as well as soil texture, and may or may not reach the point at which these salts become of serious import to agriculture.

Alkali Lands in Oregon and Washington.—If we extend the inquiry to other regions, notably to Eastern Oregon and Washington on the north, where the climatic regime is similar to that of the "Franciscan" region of California, modified mainly by the greater cold of winter, we still find the same rule to hold good. There also the bulk of the rain or snow falls in the six months from November to April inclusive, the rest of the year being practically rainless so far as any efficiency toward the leaching out of soluble soil ingredients is concerned. This is especially true of the portions of these States lying between the Cascade range on the west and the western branch of the Rocky Mountains (the Coeur d'Alene ranges) on the east, the Spokane River on the north, and the Blue Mountains on the south; excepting, of course, that portion which, on account of its proximity to the eastern chain, already enjoys a proportionally increased rainfall (to wit, the Palouse and Walla Walla country), and like Northern California can produce annual crops without irrigation. Perhaps there is no part of the United States so severely afflicted with an excess of alkali salts near the surface, as is the southern portion of what is known as the "Bend" country in Washington (Great Plain of the Columbia), with its lakes and streams of alkali water. Yet the northern half of the region is not only well suited to agriculture, but is actually rendered more so, in part, by the presence of a *moderate* amount of alkali salts. For the rainfall of this region we as yet have no data except the popular statement that it is "awfully dry" in the alkali region of the southern portion; while an increase toward the north must, apart from the successful cultivation, be inferred from the increase

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of timber as we approach the Spokane, and the fact that beyond that stream pine forests at once set in. The precipitation at Fort Spokane, not far from the junction of the river with the Columbia, is however only about 12 inches; at Ellensburg, on the upper Yakima (west of the Columbia and farther to the southward), 9 inches; and, judging from the character of the vegetation, there is even less on the lower Yakima. Throughout this region alkaline efflorescences occur on most of the lower lands; while the rolling lands, owing to the pervious (silty) character of the soils, are generally free from any noticeable taint. Fort Simcoe, lying to southward at the northern foot of the partly wooded range which borders the Columbia River to northward of The Dalles, has over 13 inches, doubtless on account of that proximity; but to eastward the forest soon terminates and the range abuts on the Yakima plain completely bare of tree growth, and largely even of shrubs, with a rainfall ranging mostly between 7 and 14 inches.

Central Montana affords an interesting field of study in respect to the limitation of alkali by the amount of rainfall. Here the city of Helena occupies nearly the same relative position toward the Rocky Mountains as does Sacramento toward the Sierra Nevada; and the rainfall of the two cities is almost identical, being close to 20 inches. Owing to the location on a slope, no alkali appears within the city; but, as at Sacramento, it comes to the surface in the trough of the plain, to northward; and, with decreasing rainfall, becomes more and more conspicuous and troublesome as we descend the Missouri toward Fort Benton; the maximum being reached (together with the minimum of rainfall so far as known—6.95 inches) in the region about Fort Shaw, on Sun River, a western tributary of the Missouri. Here, again, the perviousness of the silty soils makes the existence of alkali salts less apparent on the surface; but it becomes disagreeably obvious in the water of the springs, lakelets, and small streams of the region. East of the Missouri, the several groups and chains of mountains surrounding the Judith Basin modify the conditions of precipitation to a considerable but not as yet accurately recorded extent, leaving the northern part of that basin almost free from alkali land; but the southern portion, as well as the slopes toward, and valley of, the Musselshell River, are scarcely anywhere entirely free from the alkali taint. Toward the Yellowstone drainage area there is a gradual decrease of salts, and in the Yellowstone valley itself alkali ceases to be a matter of practical interest.

These examples suffice to show that while the presence of alkali is dependent upon a certain sufficiency of rainfall, yet that fact alone does not necessarily imply its presence to any practically important extent; the greater or less perviousness of the soil and of the sub-strata, as well as a certain slope of the surface, being effectual in counteracting the accumulation. Nevertheless, as the table of soil-composition shows, such deficiency remains potent everywhere in bringing about the main characteristics of the soils of the arid region, to wit: high percentages of lime, magnesia, and potash, and, relatively, of soda.

Alkali Lands of India.—In India we find, in the Indo-gangetic plain, a large area in which alkali ("reh") is more or less troublesome to cultivation; extending all the way from the Indus and the Arabian Sea to a little beyond the Ganges, and from the Gulf of Cutch in the south to Afghanistan on the north; including all of Sindh, Rajputana, the plains of the Punjab, the Northwest Provinces, and part of Oudh, to

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within a short distance of the Himalaya ranges; including Lahore. Within this vast region the rainfall varies from a minimum of 4.3 inches in Jacobabad, on the Afghan frontier beyond the Indus, to over 30 at Cawnpore on the Ganges. We have but very scanty data as to the extent to which alkali salts prevail to an injurious extent within this area; all the provinces mentioned above are reported as suffering from "reh" more or less; but, singularly enough, the one region in which the evil has caused the appointment of a government commission to investigate its causes and remedies, is the one which, from the amount of rainfall, one would have supposed to be exempt from alkaline efflorescences. This is the country bordering upon the rivers Jumna and Ganges, and includes the important cities of Delhi, Meerut, Agra, and Cawnpore. It is doubtless because of this fact, and of the high value of the land created by the extensive irrigation canals deriving their water from the two rivers, that the subject has here attracted such attention. The minimum rainfall occurs at Aligarh (24.3 inches), with 28.5 at Meerut and 27.6 at Delhi on the north, 26.5 at Agra and 26.7 at Etawah on the south. All these figures are materially above what in the arid region of North America appears to be the upper limit permitting of alkali efflorescences, viz.: 20 inches or thereabouts; and the question as to the cause of this difference is of considerable interest, the more as no complaints of trouble with "reh" seem to come from the Deccan, in southern India, where the same average rainfall of 24 to 30 inches prevails.

A study of the distribution of the rains through the year seems to account for the inefficacy of the rains in leaching the soil of the Northwest Provinces of its surplus salts. Unlike the "Franciscan" type of climate, in which nearly all the rainfall is concentrated within a consecutive period of six months, during which the soil is constantly kept wet enough to permit of percolation downward, the rains of northwest India fall more or less in all months of the year save November, but usually in such small amounts that no percolation is brought about; save that in the months of July and August nearly half of the annual precipitation comes down in torrential form, ill calculated to produce more than a wetting of the soil to a depth whence capillary rise will again carry the soluble salts to the surface. In the Deccan (south-central India) the distribution of the rains is less abrupt, keeping up more or less from March to December inclusive, and with fewer torrential downpours. How little the latter can do toward removing the alkali salts is strikingly apparent even in Washington and Montana, where summer thunder storms sometimes cause a sudden rise of the streams, quickly followed by dry stream beds. Such rains are as powerless to act upon the alkali in the soil as are the often repeated attempts to remove even the superficial efflorescences by quick and brief flooding. The first touch of the water dissolves the salts, and the dry soil beneath instantly absorbs the solution, leaving the bulk of the water to flow by uselessly.

While to this extent the occurrence of alkali salts in India differs somewhat from that in North America, all the rest of the characteristics of the "reh-plague" are the same in both countries, and, so far as data are available, everywhere in the world. Unfortunately, the records, even of the geological survey of India, supply but scanty details in regard to the facts, although a good deal of discussion is had, from which we glean cursorily the main features of the case. The calcareous nature of the

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"reh" soils, and their tendency to form hardpan or "kankar," which aggravates the evil, are referred to in connection with the leaching-out of the carbonate of lime from the higher slopes. The fact that the bottom water is frequently charged with salts, while deeper wells are free from any unusual taint, is mentioned in connection with the effects of irrigation; the undoubted fact that irrigation has increased the reh area is referred to, but the connection with the high-lying canals is called in question, because (as stated) no sensible dilution of the soil water has apparently taken place. Those who are familiar with the corresponding results of an exactly similar situation in California, will hardly be disposed to concur in this doubt. As regards composition, also, the exact substances constantly found in our arid regions are mentioned; only considerably greater stress is laid upon the occurrence of nitrates, and nitrate (!) of lime is mentioned as a possible good antidote for the carbonate of soda. It is not easy to see, from our point of view, how a sufficient amount of so expensive a salt should be procured for practical purposes, and why the cheap and abundant sulphate (gypsum) is not preferred in the recommendation.

Turning to *other countries* of notably deficient rainfall from which data in point are available, we find in Egypt, Arabia, Syria, and Persia, as well as in the Aralo-Caspian plains, to the northern borders of Afghanistan, a state of things quite analogous to that of the arid regions of North America and India. Soils of extraordinary and lasting fertility when irrigated; a frequent mention of calcareous hardpan or tufa on the part of observant travelers; saline efflorescences as obstacles to cultivation; saline bottom waters, barely drinkable in the shallow wells which alone the natives have found energy enough to dig: these are matters of constant mention, but too frequently attributed to the evaporation of supposed ancient salt-water basins. The climatic data available from these countries are mostly too scanty to determine what, in each of them, is the limit of rainfall beyond which alkaline salts cease to become apparent on the surface. It is interesting to note, in examining the records, how nearly the seasonal distribution and amount of rain credited to Jerusalem agrees with the "Franciscan" climate of Central California; about 22 inches falling from November to April inclusive; enabling crops to grow without irrigation and preventing the accumulation of alkali salts to any injurious extent.

I am not aware that the subject of alkali lands, and the conditions of their existence and reclamation, have attracted the attention of the *French colonies* on the African coast quite as much as the manifest importance of the subject would seem to justify. The "shotts" on the northern edge of the desert seem to be regarded as hopeless alkali sinks only, from which to obtain soda for technical uses, as is also done in Fezzan.

Pretty much the same indifference appears in Europe, in the *Hungarian Plain*, where the gathering of "shekso" or crude soda, rather than cultivation, seems to be the destiny of the alkali lands. Popularly the light and heavy varieties of these lands are distinguished as "szek" and "szik" respectively. With a rainfall of about 24 inches, these lands differ from the ordinary alkali lands in that their salts are supplied them from a saline stratum below the subsoil, instead of being generated in the soil itself; in other respects, however, the phenomena and the practical outcome are identical, including even the extreme productiveness of the

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heavier soils close to the border of spots incrusted with salts. The latter vary, as in California, from almost pure carbonate to mixtures of Glauber's and common salt, which have in the past formed articles of commerce. Without doubt the same processes of reclamation are applicable to them as those which are proving so successful in the case of the alkali soils of California; and the attention of the Hungarian government has been awakened by the results obtained in this State.

COMPOSITION OF ALKALI SALTS IN DIFFERENT REGIONS.

In order to show the nature and possible functions of the alkali salts in soils I give below a table of analyses, selected from a large number, to show the great variety, as well as certain coincidences of composition, wherever found.

It will be seen that all over the world the saline efflorescences occurring over wide acres and owing their existence to general causes, have as their prominent ingredients the three sodium salts—*chlorid* (common salt), *sulphate* (Glauber's salt), and *carbonate* (sal soda). The relative proportions of these vary greatly, especially as regards the chlorid and carbonate; the sulphate is on the whole the one most invariably present in considerable proportion. In addition to these we find, usually in relatively small proportions, what might be called accessory ingredients, depending more or less upon local conditions, climatic as well as geological, but frequently of very great practical importance. Among these, the salts of potassium (potash), the nitrates, and the phosphates are of particular interest to agriculture, since they represent three elements usually supplied in fertilizers; whence it follows that their presence in the soluble form in such proportions as to participate in the formation of alkali crusts on the surface, is of no mean interest to the farmer, since it argues the occurrence of an excess of plant food in the soil, and therefore the needlessness of fertilization while this state of things continues.

It is therefore of special interest to determine to what extent the presence or absence of these accessories is dependent upon climatic conditions, and what local conditions may modify the result.

Nitrates.—Of the accessory ingredients the one most manifestly dependent upon climatic conditions is the nitrates. It is well known that the process upon which their formation depends is materially conditioned upon a certain high temperature (about 75° Fahr.); a moderate degree of moisture, permitting the easy access of air and forbidding the existence of reductive fermentations; the presence of calcic or magnesic carbonate; and most of all, upon that of the "nitrifying organism," without which the other conditions are powerless to act. Anything that paralyzes or destroys that organism is fatal to nitrification.

Among the ingredients that might be considered as certainly injurious to the life of the organisms in question are the chlorids of calcium and magnesium (bittern), and the carbonate of soda (and potash) when present in any large proportion, *e. g.*, so as to dissolve the humus of the soil, forming what is familiarly known as "black alkali." We should therefore expect to find nitrates scarce or absent where large percentages of carbonate of soda are found in the alkali salts, and relatively abundant when sulphate and chlorid are chiefly present. Actual examination fully confirms this *a priori* conclusion; the occurrence of

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NOTE.—To facilitate
of the efflorescences, exa

Com

Potassium sulphate (K	
Sodium sulphate (Na_2	
Sodium carbonate (Na	
Sodium chlorid (NaCl	
Sodium phosphate (N	
Magnesium sulphate (	
Magnesium chloride (	
Totals	

*Also called "kara,"

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nitrates in large proportion is confined to those regions in which "white alkali" is predominant; that is, neutral salts whose presence does not injure the activity of the nitrifying organism. This is confirmed also by the fact that the niter-beds of South America, as well as those of Nevada (White Plains) contains the saltpeter associated only with the two neutral salts, sulphate and chlorid of sodium. The same rule will be observed to hold good in the cases in which nitrates are found in notable amounts in the alkali salts from California and Montana, of which analyses are given above. No nitrates are found in the highly carbonated salts of Washington.

We have thus in the necessarily calcareous nature of the soils of the arid region the fulfillment of one necessary condition of ready nitrification; in the moderate moisture-condition of the soils of the same region, a favoring condition so far as oxidation is concerned, together with the substitution of eremacausis of the soil humus in the place of the fermentations that under humid conditions frequently not only arrest all oxidation but also, by the formation of poisonous compounds (ferrous and manganous salts), actually destroy the life of the nitrifying organism. Even the exceptional condition of a strong impregnation with carbonates of the alkalies does not act as unfavorably upon plant nutrition as might be inferred, for it is apparent from the analytical record as well as from the evidences of the senses, that in that case the evolution of ammonia from the humus can serve as a source of direct supply to vegetation; and finally, whatever nitrates are formed are not, as in humid climates, liable to be leached currently from the soil beyond the reach of plants, but remain year after year in actual accumulation. We are thus justified in the conclusion that aridity is peculiarly favorable to the supplying of nitrogen to plants.

Potash.—While the presence of this substance is to some extent dependent upon the character of the country rock, being often very high where granites contribute largely to the soils; yet its accumulation in the soils themselves seems to follow, as a matter of course, along with, and in preference to, the sodium salts; the cause of the difference being its more tenacious retention by the soil. As regards the water-soluble salts, it is probable that where no potash appears in the analysis of an alkali salt, it has simply been overlooked or neglected. It will be noted that in California and Montana potash salts frequently constitute from 7 to 10 per cent of the whole mass of "alkali"; forming a supply that, when calculated to the soil mass to the depth to which the roots of crops are likely to reach. promises to defer indefinitely the need of supplying potash fertilizers to such soils. There does not appear to be any definite relation between the amounts of potash present and the neutral or carbonated condition of the salts.

Phosphoric Acid, or Phosphates.—The slight solubility of earthy phosphates of necessity relegates the abundant occurrence of soluble phosphates to the cases where the salts are highly carbonated; it is therefore chiefly in the very "black" alkali that we find notable amounts of dissolved (sodic) phosphate. But in some cases these amounts are sufficient to promise the farmer, as in the case of potash salts and nitrates, a long exemption from the purchase of phosphate fertilizers.

In view of these facts it seems abundantly worth while to examine carefully the conditions under which the two types of alkali salts—the neutral, or "white," and the alkaline (carbonated), or "black"—respect-

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ively occur, and to what extent we may be able to control their injurious effects upon vegetation.

Formation of Natural Deposits of Carbonate of Soda.—It is curious to search in the past and even current literature on the general subject, for a reasonable explanation of the occurrence of carbonate of soda in nature. There seems to be a consensus of opinion that the carbonation of the soda is in some way connected with the presence of limestone or carbonate of lime, and that an exchange has occurred in which either common salt or Glauber's salt have transferred their acidic components to lime and have become carbonates instead. But how such an exchange is to be effected, in view of the exactly opposite reaction that occurs when alkali carbonates and earth sulphates or chlorids are brought in contact in our laboratories, has led to many wild conjectures without a tangible basis.

Yet the simple explanation of the contrary reaction was given and published as early as 1826, by Schweigger; in 1859 it was again observed by Alex. Müller, in a different form; but neither these chemists, nor any of their readers, appear to have perceived the important bearing of this reaction, not only upon the formation of the natural deposits of carbonate of soda, but also upon a multitude of processes in chemical geology.

Without going into detail, which has been published elsewhere,* it may be broadly stated that the formation of carbonated alkalies occurs whenever the neutral alkaline salts (chlorids or sulphates) are placed in presence of lime or magnesia carbonates *and* carbonic acid, or of alkali "super-carbonates." (hydro-carbonates) containing even a slight excess of carbonic acid above the normal carbonate; being the actual condition of all natural "sodas." In that case, crystals of gypsum may be seen, *e. g.*, in the residue from the evaporation of a mineral water which nevertheless shows a strong alkaline reaction; and such alkaline reaction is also obtained when carbonic gas is passed into a solution of common salt in which calcic carbonate is kept suspended, the formation of calcic chlorid being simultaneous with that of the alkali hydro-carbonate.

It is easy to see that these conditions are constantly being fulfilled in nature; for the decay and fermentation of vegetable matter is constantly progressing in soils, swamps, and lakes, and as evaporation progresses the alkaline carbonate crystallizes out on the surface, or margins, while gypsum or calcium chlorid accumulates on the bottom, or in the waters.

It has been shown above that the soils of arid regions are almost necessarily calcareous, free carbonate of lime being present; as are also the salts of the alkalies. The conditions for the formation of carbonates of the alkalies just recited, are therefore fulfilled wherever enough of vegetable decay (or evolution of carbonic gas from other causes) goes on so as to impart even a slight excess of carbonic acid to the soil or other water; and thus "black alkali" is formed, to an extent depending upon the excess of carbonic acid available for the process. It is evident that this excess will be greater in moist, close soils, rich in humus, than in loose and pervious ones; and thus the fact that "black alkali" is mainly found in low ground, and in rather close soils, finds a ready explanation.

* Proceedings of the American Association for the Promotion of Agricultural Science, for 1888 and 1890.

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But since vegetable decay is essentially dependent upon a certain elevation of temperature, and is totally suppressed by a certain degree of cold: it follows that, other things being equal, the formation of the alkaline carbonates will be most abundant in warm climates. The record of the occurrence of the "soda" deposits that in time past were of such industrial importance as the only sources of sodic carbonate, answers fully the requirements of this condition. Egypt, the African arid region generally, Mexico, the Aralo-Caspian lowlands, Turkestan, and the arid regions of western India, are the well-known sources from which the supplies of the "mineral alkali" (Trona, Urao) were formerly obtained. Were not the reaction limited to relatively dilute solutions,* its cheapness would soon drive all other processes of soda manufacture out of existence.

We do not therefore ordinarily expect to find alkaline carbonates abundant in the colder portions of the arid region; and this, as the table shows, is pointedly true as regards Montana. But in Washington, practically in the same latitude, the showing is quite different; we find here not only the carbonate of soda predominant, but it is present in percentages as high as those which in Montana and California are shown by the Glauber's salt.

But examination also shows, in the case of Washington, a special cause for this state of things. Almost the entire area on which alkali occurs in that State is covered by the black eruptive rocks commonly, although to a great extent improperly, called basalts. As eruptives, these rocks are, of course, entirely free from gypsum, and but very rarely show even a. trace of sulphurets. There is therefore no source from which sulphates could derive their essential ingredient; and thus the sodic carbonate originally formed in the decomposition of the basalt by the atmospheric agencies simply continues unchanged, as it emerges with the spring waters from the crevices of the rocks. Yet in a few cases, where the basaltic eruptives are overlaid by a somewhat considerable mass of stratified (cretaceous and tertiary) deposits, the sodic carbonate is in the minority, and as in Montana, the sulphate predominates.

That such local accidents as these should bring about apparent contradictions is to be expected; yet even in this case they prove the rule.

In the summary review of the relation of climate to soils—the two factors which essentially control the production of the necessaries of life—that forms the subject of this paper, the scantiness and incompleteness of the data thus far available on a topic as interesting theoretically as practically important, is painfully apparent; and to no one more so than to the writer himself, who has made soil studies a favorite pursuit during most of his active life. While the intrinsic difficulties to be met in such an investigation are sufficiently great, the remarkable looseness of observations bearing upon it, their usually sporadic and unsystematic nature, and the fact that they are so thinly scattered in various kinds of literature: travels, geography, statistics, reports on geological, topographical, and even botanical topics, together with encyclopedias and miscellaneous technical works of reference, renders their collation and elaboration very laborious, and thus far rather unsatisfactory. It should not therefore be surprising to any one if in this first attempt at a systematic exposition of the subject there are many impor-

* The limit is reached at about 0.4 per cent.

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tant gaps and omissions that might have been avoided had a more complete library and a larger share of leisure been at command. It may be hoped, however, that this paper may serve at least the purpose of enlisting in the study of this, the latest phase of chemical geology, a larger number of active workers and observers, so that at least, the large amount of information actually existing may be gathered together and made practically useful; thus leading the way to a better understanding of the character, capabilities, and needs of the lands of the various regions, and of the means of utilizing them to the best advantage. The eminently practical nature of such investigations should commend them to greater attention from public geological surveys, in which a vast amount of labor is devoted to subjects of very much less interest and importance, whether theoretical or practical. The apathy that has prevailed in regard to these studies would be difficult to understand but for two considerations, one historical, the other intrinsic. From the latter point of view, the undeniable difficulty and complexity of the subject of soil study, and the want of immediately brilliant and remunerative results to the worker, is no mean deterrent factor. Historically, direct soil-investigation received a set-back in the early part of this century, when upon extravagant expectations from its application to agriculture there followed a reaction which has not even yet subsided entirely. But it certainly is high time that such prejudices should give way to a reasonable reconsideration of the facts from a modern scientific standpoint; and that in the prosecution of public surveys, the interests of agriculture should cease to be the stepchild of which the name is used only for the sake of conciliating the favor of the large class dependent upon its intelligent prosecution. Conjointly with the study of soils that of climatic conditions is of the utmost practical and theoretical importance; and ample means for the prosecution of both branches of study should be provided. The Experiment Stations of the United States, as now constituted, have not the means for a sufficiently rapid and energetic prosecution of either, to respond to the demands made upon them. Meteorological stations must be made much more numerous, and should largely be located with reference to the agricultural problems to be determined in connection with them. Actual field surveys to define the agricultural subdivisions and to study their peculiarities, should be made by parties covering ably not only the agricultural, but also the meteorological, geological, and botanical aspects of the several problems. This will be but simple and tardy justice to the fundamental industry upon which the very existence of nations depends everywhere.

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II. ALKALI AND ALKALI SOILS.

The study of alkali soils, and especially of the methods of reclamation and the cultural value when reclaimed, has continued to engage considerable time and attention. As cultivation and irrigation in the interior valleys of California are extended, the inconvenience of having culture areas interrupted by streaks or spots of alkali land, and the expansion of alkali areas under irrigation, attract more and more attention to the need of dealing in a definite manner with the subject. Moreover, the rise of the alkali in consequence of irrigation, in lands before entirely free from any indication of the kind, is liable to cause not only inconvenience, but serious loss, in the older settled regions.

Since it has been conclusively shown that the vast majority of alkali lands when reclaimed become both highly and lastingly productive in consequence of the extraordinary amounts of soluble mineral plant food present in them, attention has been drawn to considerable areas which, while lying convenient to railroad communication, have heretofore been neglected because of the obvious presence of alkali. The Station has frequently received requests for the examinations of such soils, in order to determine their fitness for reclamation and culture; and thus it has become necessary to determine more closely both the amount and kind of alkali salts compatible with the welfare of the several culture plants. In the progress of such investigations, it has become apparent that this question is very much more complex than had been anticipated; since not only the indefinitely varying proportions of the total alkali salts in the soil, and of the several ingredients amongst themselves, but also the physical nature of the soil (closeness, looseness, heaviness, lightness, sub-soil conditions, depth and nature of bottom water, etc.) have to be taken into consideration. Among the latest difficulties encountered is the unexpected fact, definitely demonstrated by the investigation of Mr. Colemore, given below, that the alkali salts may vary very materially, *horizontally*, within one and the same "spot," as well as vertically, as heretofore shown. The causes and extent of these remarkable differences have yet to be ascertained and studied in a more general manner.

It is to be hoped that those directly interested in the reclamation of alkali lands, or in the prevention of the damage to plantations already established, will lend their aid in supplying information and specimens toward these studies, discarding the reticence which many have heretofore deemed it necessary to observe regarding the occurrence of alkali on their lands. The fabled ostrich in hiding its head in the sand to escape its pursuers, might claim an equal degree of foresight and prudence.

A number of analyses already completed are omitted from the present record, as their discussion will be more fruitful in connection with other work now in hand.

E. W. H.

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THE AMOUNT AND KIND OF SOLUBLE SALTS PRESENT IN DIFFERENT PORTIONS OF AN ALKALI SPOT, FROM THE CENTER TO THE CIRCUMFERENCE.

By CHARLES COLEMORE, of San Francisco, U. C., 1894.

The object of the present series of investigations was to determine the amount and kind of alkali in an alkali spot which would injure plant life. Beginning at the central portion of such a plot and advancing toward the edges, we find the following conditions: At the center there is no vegetation whatever, while at a point near the edge vegetation begins to appear, and finally we reach a point where the growth is normal. Such are the physical aspects of an alkali spot of the type known as black alkali, and would seem to indicate a variation in the chemical composition of the alkali in the soil; the present investigation goes to show that such a variation does exist.

Samples for examination were taken to a foot in depth from an alkali spot near the Tulare Experiment Station, by the foreman, and at a distance of 4 feet from each other, so as to represent as nearly as possible a cross-section of the tract. In the following table, No. 1 represents the central part of the spot, while No. 5 was taken on the outer edge, where alfalfa and wheat were growing.

An inspection of the table will show that there is a decrease in the amount of sodic carbonate from 35.50 in the center to 23.86 in soil No. 5 or outer edge. This is the most deleterious of the salts present in "black alkali" regions, as it keeps organic matter in solution and corrodes and burns the roots of all growing vegetation. In soils Nos. 1, 2, and 3 it exists in quantities sufficient to almost totally prevent the germination of seed, while in soils Nos. 4 and 5 seeds germinate and grow. Culture tests on the samples showed that of the ten wheat seeds planted in soil No. 1, only one germinated, and that grew to be only one half an inch high when it withered and died. In soils Nos. 2 and 3 nothing grew, while in No. 4 seven of the ten seeds germinated and grew fairly well. In soil No. 5 eight or nine grew and flourished, producing better and earlier plants than in No. 4.

The amount of organic matter held in solution, though variable, shows a general decrease from No. 1 to No. 5, while the sulphuric acid increases regularly from No. 1 to No. 5, and being combined with potash and soda to form neutral salts it renders the alkali more bland and non-corrosive.

TABLE I.

Amount of Soluble Matter at Various Points of the Section of Alkali Spot. (First foot in depth.)

Samples Taken.	Total, Inclusive of Organic Matter.	Mineral Salts.
No. 1, center of spot	0.679	0.377
No. 2, next to center	.539	.397
No. 3, intermediate	.697	.535
No. 4, next to outer edge	.370	.250
No. 5, outer edge of spot	.337	.229

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TABLE II.

Percentage Composition of Soluble Alkali in Various Portions of Alkali Spot.

	No. 1. Center of Spot.	No. 2. Next to Center.	No. 3. Interme-diate.	No. 4. Next to Outer Edge.	No. 5. Outer Edge of Spot.
Potassic sulphate	4.69	7.09	9.60	10.93	11.11
Sodic sulphate	13.89	9.53	19.10	18.37	13.51
Magnesic sulphate	2.15	.02	.77	1.57	6.61
Sodium chlorid	9.65	17.61	19.42	18.57	23.66
Sodic carbonate	35.50	37.81	30.24	27.20	23.86
Sodic phosphate	3.90	2.14	.70	----------	.83
Sodic nitrate	.22	Not deter.	.69	Not deter.	.11
Organic matter	30.00	24.80	19.48	23.36	20.31

TABLE III.

Percentages of Inorganic Substances at Various Points of Alkali Spot.

	No. 1. Center of Spot.	No. 2. Next to Center.	No. 3. Interme-diate.	No. 4. Next to Outer Edge.	No. 5. Outer Edge of Spot.
Potash	3.65	5.06	6.57	6.13	7.84
Soda	50.91	49.51	45.25	48.37	41.24
Magnesia	1.04	.09	.33	.68	.30
Chlorine	8.46	13.91	14.32	14.84	18.24
Carbonic acid	20.70	18.69	15.62	14.95	12.67
Sulphuric acid	14.18	14.48	20.17	18.31	22.99
Phosphoric acid	2.71	1.36	.36	----------	.52
Nitric acid	.20	Not deter.	.55	Not deter.	.09
	101.85	103.14	103.17	103.28	103.99
Less oxygen due to Cl	1.85	3.14	3.17	3.28	3.99
Totals	100.00	100.00	100.00	100.00	100.00

TABLE IV.

Percentage Composition of Alkali Salts. (Compounds calculated without organic matter.)

Mineral Salts.	No. 1. Center of Spot.	No. 2. Next to Center.	No. 3. Interme-diate.	No. 4. Next to Outer Edge.	No. 5. Outer Edge of Spot.
Potassium sulphate	6.70	9.55	11.92	14.26	13.95
Sodium sulphate	19.84	12.85	23.72	23.97	16.96
Magnesium sulphate	3.07	.07	.95	2.05	8.29
Sodium chlorid	13.80	23.73	24.12	24.23	29.68
Sodium carbonate	50.72	50.96	37.55	35.49	29.94
Sodium phosphate	5.57	2.88	.87	----------	1.04
Sodium nitrate	.30	Not deter.	.87	Not deter.	.13
Totals	100.00	100.00	100.00	100.00	100.00

COMMENTS ON THE RESULTS OBTAINED BY MR. COLEMORE.

In the investigations on the alkali question heretofore made at this Station, the great and, from a practical point of view, often very important differences in the nature of the alkali salts from neighboring tracts, have repeatedly attracted attention. Since from late observations it appeared that the composition of the salts differs at different depths even in one and the same spot, it became probable that even greater differences would appear if the composition at different horizontal points in one and the same spot were tested.

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As is well known, the sporadic alkali spots found in level tracts are usually more or less basin-shaped, the center of the (usually approximately circular) spots being a few inches to a foot and even more below the general surface of the ground. The cause of this depression is the destruction of the flocculated or "crumby" structure of the soil (constituting "tilth") by the action of carbonate of soda, which consolidates the earth into compact, tough sheets of hardpan. As the "white" (neutral) alkali exerts no such effects, the existence of these depressions, and their extent, marks in a measure the intensity of the carbonate-of-soda plague.

Since in the case of rain or irrigation the tendency would be to wash the salts from the margin of the basin toward the middle, the fact shown in Table I, that the largest total amount of salts is found at or near the middle or lowest portion of the spot, was to be foreseen. Correlative with this we may expect to find a more or less regular decrease toward the margin, such as is shown in the table, until we reach, at that margin itself, the limit beyond which normal vegetation can not only exist without injury, but can render manifest by its luxuriance the extraordinary intrinsic productive capacity of the alkali soils.

It will be noted that this maximum amount here found to be compatible with ordinary (weed) vegetation is 0.23 per cent, or a little less than a quarter of one per cent of total soluble salts; of which, however, nearly one third was carbonate of soda, and nearly another third common salt; or nearly 0.08 per cent of the soil of each. This amount of carbonate of soda was found sufficient, in an adobe soil near Stockton,* to prevent tillage and any useful plant growth; while in the lighter soil of Tulare such growth *is* successful, notwithstanding the additional presence of an equal amount of common salt, which, as experience has shown, is much more injurious than Glauber's salt.

It is thus obvious that the mere determination of the *amount* of total salts present in a soil is not sufficient to determine its fitness or unfitness for crop growth; it is essential that the *nature* and *proportion* of the different salts present should be determined, before a definite judgment can be had.

Nature of the Alkali Salts at different Points of the Spot.—Tables II, III, and IV show the variations in the composition of the alkali salts from center to margin.

Table II is chiefly interesting as showing the various amounts of organic matter (here mainly humus or vegetable mold) dissolved by the different qualities of alkali salts. While not altogether regular in its increase from the margin toward the center, doubtless on account of differences in the nature of the matter dissolved, it is clearly apparent that the largest amount is dissolved by the alkali containing the largest proportion of carbonate of soda; as might have been foreseen.

Table III, in which the several mineral ingredients are set down in the form resulting from analysis, and Table IV, in which the elements are placed in their most probable combinations, show more plainly the important changes of composition from center to margin, because of elimination of the organic substance from the calculation. We thus obtain a very much more consistent series of figures for most of the ingredients. Most striking of all, perhaps, is the fact that while *soda*

* See Report of the College of Agriculture for 1879, p. 34; also separate issue of report on "Alkali Lands, Irrigation and Drainage," 1886, p. 9.

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shows a steady increase (from nearly 41 to 51 per cent) from the margin toward the center, *potash*, on the contrary, shows the reverse progression, namely, an increase from 3.65 at the center to 7.84 at the margin. The cause of this reversal is, doubtless, the comparative slight solubility of potash sulphate as compared with sodic sulphate; from which there results a tendency to leave the potash salts behind. This explanation is corroborated by the figures for sulphuric acid and magnesia; the latter showing the wandering of the soluble magnesium chlorid toward the center, while the sulphates remain behind.

But perhaps the most important of the differences is shown by the figures for *carbonic acid*, which show a remarkably regular increase of the noxious carbonate of soda from the margin toward the center, where more than half of the total salts is this carbonate. A similar increase from the margin toward the center is noted for the phosphates.

Since the solubilities of carbonate and sulphate of soda do not differ very widely, this increase of carbonate must be due to some other cause. The true one is doubtless to be found in the greater degree of moisture which throughout the season exists toward the middle of the spot; favoring in a marked degree the formation of carbonic acid, which as I have heretofore shown* is in connection with lime carbonate, the active agent in transforming sulphates and chlorids of alkalies into carbonates. It is entirely parallel to the wider fact heretofore mentioned by me that "black" alkali is by far more predominant on low than on high ground; *e. g.*, in the flood plains of streams, as against the adjacent bench lands.

That *phosphoric acid*, or rather alkaline phosphates, should follow the same rule as the carbonate, I have also heretofore discussed in connection with the almost universal fact that neutral or "white" alkali salts usually contain only traces of phosphates. That strong solutions of alkaline carbonates should tend to decompose the earthy and metallic phosphates of the soils, so as to form alkaline hydro-phosphates, while no such action can be looked for from neutral salts, is obvious.

A glance at the data concerning *chlorine* exhibits a decrease from the margin toward the center even greater proportionally than in the case of potash, and less only in that of phosphates. It is fairly supposable that this decrease is in the main due to the slighter solubility of common salt as compared with Glauber's salt, so that while the latter is washed toward the center the common salt tends to remain near the margin.

As regards *nitrates*, the determinations, as far as they go, indicate that while they are leached from the margin toward the center, their absolute amount is not a maximum at the latter point, but about half way between. This is quite intelligible when we consider that not only must nitrification cease in presence of so excessive an amount of carbonate of soda, but that in addition the very process of fermentation, upon which (as above mentioned) the formation of that carbonate depends, may, by reduction, destroy nitrates already formed, and may even give rise to the formation of ammonia salts, the occasional presence of which in alkali soils has seemed so enigmatical.

From the practical standpoint the facts, as here shown, emphasise the need of more energetic measures in reclaiming the lower portions of

* Alkali Lands, Irrigation and Drainage, p. 24.

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ALKALI CORNER PREVIOUS TO THE GYPSUM EXPERIMENT. (All Alkali, but white spots much stronger.

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alkali streaks in general, as compared with higher ground, whether in the more abundant use of gypsum to neutralize the black alkali, or more effective drainage for leaching out the surplus salts. (E. W. H.)

RECLAMATION OF ALKALI LAND WITH GYPSUM AT THE TULARE STATION.

By C. H. Shinn, Inspector of Stations.

The high degree of success which has now been gained with the alkali reclamation plots at the Tulare Experiment Station, justifies a review of the system pursued and the results obtained there. The illustrations annexed are reproduced directly from photographs. A few details might be shown better by drawings, but the accuracy and authenticity of the photographic process are incontestable, and accuracy in this case is all-important.

The experiment of reclamation was commenced in 1890, in the northeast corner of the Station tract, where the strongest alkali existed. Here, over about an acre, there was no vegetation, not even weeds, and all attempts to grow crops had wholly failed. Even in less strong alkali tracts adjoining this acre, beets, sorghum, and cereals could not be grown successfully. The experiment was therefore intentionally made upon the worst "alkali sink" in the region—a tract hard to duplicate, and containing much more of the "black alkali" (about two per cent) than would ordinarily occur in experiments upon a large scale.

Plot No. 1, as laid off in 1890 in this northeast corner, contained one fourth of an acre. It was cheaply underdrained by means of three redwood drains, shaped like an inverted V, and placed about three feet below the surface. These drains united, and discharged into a drainage-pit, or sump (shown in the photograph below), dug in the edge of a small, shallow slough, and carrying the water into the gravel beds beneath. Some system of drainage was made necessary upon this plot because of the intensity of the alkali, and its great extent, not only on the Station tract, but in adjoining fields. Mere surface treatment, without drainage, would have changed the nature of the alkali ("black" to "white"), but it would still have left in the soil too large a proportion of salts for the growth of any useful vegetation.

In constructing this drainage system, cheapness was important, and it was put into operation at a cash outlay of less than $50. On a larger scale, and in light or sandy soils, it could doubtless be done with more permanent materials and with an outlay of $30 per acre.

A second plot of three fourths of an acre, adjacent to Plot No. 1, was experimented with upon another plan. No sump nor underdrainage was used, but the hardpan was merely broken up with charges of blasting powder, at intervals of 10 feet apart, and at a total outlay of less than $10.

The effect of gypsum on the hard and tough clods of hardpan was well observed in this treatment. Shortly after the water was turned on so as to enable the gypsum to exert its influence, the clods began to soften and crumble off on the outside, and in a few days were transformed into piles of crumbs much more bulky than the original masses.

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So far this method, at the Tulare Station at least, seems to have served nearly as well as the more costly underdraining with rough redwood, but in localities where the gravel lies deeper than 12 to 15 feet, drains of some sort would probably be necessary to reclaim alkali as strong as that under consideration.

The one fourth of an acre (Plot No. 1) was surrounded by an embankment, thrown up with plow and spade, and was divided for convenience in handling into two nearly equal parts, separated by a cross dike. The surface, which was extraordinarily hard and difficult to work, was plowed and deeply broken five times in 1890. Masses of the "hardpan" were pounded up with axe and crowbar. After each plowing gypsum was spread on the surface and harrowed in. Water was immediately turned on, and allowed to stand three inches deep over the plot for several weeks at a time; it gradually soaked down, and passed out into the sump, dissolving and carrying off the salts, while neutralizing the "black alkali." After the fourth plowing and treatment with gypsum, sugar-beets were sown, but the seed failed to germinate in the soil, still too strongly impregnated with alkali to carry any vegetation. This attempt to grow beets closed the season of 1890, during which gypsum had been used at the rate of 500 pounds to the acre. It was thoroughly incorporated with the surface foot of soil, and leached through the upper three feet of soil, to the level of the drains. None of it was wasted. Ten times as much, merely spread on the surface and left to the weather, would have been less effective than this small quantity worked into the soil.

The second and third years, 1891 and 1892, the same kind of treatment was extended to the larger plot, which had been prepared by blasting for drainage. It was observed that the operation of the gypsum was somewhat slower here, and that a larger amount was required, as it sank deeper where the blasts had been made, and hence wasted faster.

During 1891 and 1892 the original plot of one fourth of an acre was several times plowed, broken up with pick-axe and spade, dressed with gypsum, and irrigated, as before. It was still found that seeds would not germinate well, though the percentage of injurious salts was greatly lessened. In 1891 a few beets sprouted and made three or four pairs of leaves before they perished. A few barley spears grew one or two inches above the surface, turned yellow, and died. In the autumn of 1891 straw was freely plowed in to keep the soil from "running together" into a hard, almost impenetrable mass. Four workings in all the plot received in 1891, and four more in the following year, 1892.

The cultures attempted in the spring of 1892 were more varied than before, embracing beets, corn, sorghum, cereals, grasses, clovers, and some garden crops. Most of these were sown in short rows near the middle of the plot, and the rows received a special application of gypsum to better protect the seed. Results showed the effect of the underdrains; the nearer the plants stood to the line of a drain the better they grew. While many cultures failed entirely, there was much to encourage hopefulness. Sorghum and Egyptian corn in some cases grew six or seven feet high, and yielded heavily. Close beside such plants as these were others hardly three inches high, pygmies of the same age, stunted by the alkali. A few barley plants were normal, but most of them when headed out were only three or four inches high. It was evident that the leaching of the plot had been very uneven, owing to the

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ALKALI CORNER OF TULARE EXPERIMENT STATION. (Alkali sump in foreground; reclaimed Alkali ground, with grain crop, in background.)

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hardness of the soil; and most of the gypsum used in 1892 was used upon the spots where the alkali still remained strongest.

By the close of the year 1892 gypsum had been used on the plot at the rate of 2,000 pounds per acre, and it was thought to be time to make a field test on a larger scale. In December, the foreman, Mr. Forrer, plowed in all the straw the land would bear, and sowed wheat and barley the last week of the month for the crop of 1893. It proved to be a fair season in the district. No water was applied nor any more gypsum until after the crop was harvested. The straw plowed in kept the surface loose, and the grain germinated well. It grew rank and tall, excepting in two or three very small spots. The wheat yielded at the rate of 45 bushels to the acre, and the barley did even better. Some of the best stalks were nearly five feet high, and the average stand was four feet. The plot was visited by many farmers who said that there was no finer grain growing in the district, and acknowledged the success of the experiment. The photograph represents the plot as it appeared just before the grain was cut: One of the visiting farmers is sitting on the dike; the foreman is standing near. This grain was thus grown, after three years' treatment, upon the worst portion of the alkali corner of the Station tract—land that in a natural state produced nothing, not even weeds or pasturage. The grain was finally cut and specimens sent to the Central Station at Berkeley, where it is kept for illustration. They were also placed on exhibition at the Midwinter Fair in the station alcove of the University exhibit. The accompanying photograph gives the relative height and appearance of the several samples. At one end are also specimens of wheat from a medium alkali spot where the grain has just been able to grow to a few inches, while on adjoining plots it had attained a height of several feet.

Meanwhile, on the other plots, the three fourths of an acre where blasting powder had been used, the land was broken even more deeply than on Plot No. 1, by a process of trenching with plow and spade, and gypsum and straw were mixed with the soil. The leaching here proceeds more slowly than on the first plot, but good progress has been made, and another season a fair crop of wheat and barley can be expected.

The one-fourth acre plot was treated with another dressing of gypsum late in 1893, and, on December 20th, cereals were again sown there, and also upon the three quarters of an acre adjoining, where blasting powder had been used. A poorer crop was looked for from the latter, but it seemed desirable to see where additional applications of gypsum were necessary. All the seed started well, and grew fast until six inches high. The severe cold and drought of the disastrous spring of 1894 then checked, and finally destroyed all the grain on the three-quarters acre plot. Upon the smaller, and best reclaimed plot, a half crop was obtained, greatly to the surprise of the farmers, who had watched the experiment with especial interest on account of the untoward season. It would have been easy to have irrigated all the plots, but this would have destroyed the value of the test, under such climatic difficulties. The total rainfall was less than five inches, and the drying northers were very severe.

Summing up the work done in five years on this experiment: the total amount of gypsum used upon the acre now under treatment is 3,000 pounds. Only 625 pounds has gone on the first one fourth of an acre, which was underdrained. This was at the rate of one and one fourth

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tons to the acre. The plots on which blasting powder was used have required 2,375 pounds of gypsum, or at the rate of nearly 3,200 pounds to the acre, and are not yet as far reclaimed as the first plot. They will probably require half a ton more to yield wheat and barley at the rate of last year's crop on Plot No. 1. The gypsum is evidently distributed more evenly and therefore more effectively by the method of underdraining, where the conditions are similar to those that prevail at the Tulare Station.

REMARKS ON THE ABOVE EXPERIMENT.

The above description of the reclamation experiment shows some of the characteristic points to be observed and difficulties to be encountered in the reclamation of alkali lands. It must, of course, be fully understood that the procedures here made use of were tentative and purely with a view to study, and without present reference to expense. As stated by Mr. Shinn, the spot chosen for the operations was probably as bad a case as could be found in the whole alkali region. The entire soil-mass had been consolidated ("run together") into compact sheets of impervious hardpan of puddled clay and fine sand; almost completely untractable under the plow, and even when reduced to something like tilth by main strength, returning to its original condition of compact, resistant, tough hardpan at the first wetting. Analyses had showed this hardpan to contain from 2 to 3 per cent of soluble salts; an amount by far too large, according to all experience had, to permit of either the germination or growth of any plant, especially so long as any considerable proportion (usually about one third) of these salts consisted of carbonate of soda. European experiments on coast marsh soils give one fourth of 1 per cent (0.25%) of salts as the limit consistent with useful cultures; in the present case we have to deal with ten times that amount of salts of a much more noxious nature.

Our observations have, however, long demonstrated that Glauber's salt, or sulphate of soda, exerts a much less noxious influence upon plant-growth than common salt; and since this is the compound formed from "black alkali" when neutralized with gypsum, the remarkable change in the producing power of land which was entirely useless in its unreclaimed condition, is readily intelligible.

In the pamphlet issued by the Station on this subject, and reprinted in 1892, special attention is called to the need of preventing surface evaporation, and the formation of a crust in which the alkali could accumulate, so as to injure the surface roots and root-crown, or to prevent germination of seeds. This is the obvious cause of the effectiveness of straw in aiding reclamation by means of gypsum or underdrainage; not because of any fertilizing effect, as has been imagined by some, who thought of improving upon straw by the use of stable manure in the same way.

It should be distinctly understood that wherever "black alkali" exists, the use of stable manure to effect the loosening of the soil may materially *injure* instead of improving the effect, by the setting free of corrosive ammonia vapors, which destroy the vitality of seeds. In none of the alkali lands thus far examined by us is there the slightest occasion for the addition of fertilizing ingredients, which are invariably present in the soluble salts themselves to an extent not only far exceeding that

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On Medium Alkali. Partly Reclaimed Alkali Soil. On Fully Reclaimed Alkali Soil.

WHEAT AND BARLEY GRAIN ON ALKALI LAND TREATED WITH GYPSUM.

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supplied by any ordinary dose of fertilizer, but which, being perpetually supplemented from below, must for a series of years render all fertilization unnecessary. The high productiveness of alkali lands illustrated in the above experiments, and substantiated wherever the effects of the noxious salts have been done away with by under-drainage or gypsum treatment—illustrated in fact by the enormously rank growth of weeds on the edge of every alkali spot—is readily and strikingly explained by the analyses of alkali salts, given in the present as well as in previous reports.

It may not be superfluous to call attention here, once more, to the fact demonstrated by us fourteen years ago, that less than one tenth per cent of carbonate of soda or "black alkali" in a clay soil will render it unproductive and frequently untillable; while the corresponding amount of Glauber's salts formed when such soils are treated with gypsum, is completely innocuous. As there are very extensive areas of soils whose cultivation is at present rendered unprofitable by just such a slight taint of carbonate of soda, it follows that these same lands can be reclaimed for culture not only profitable, but exhibiting extraordinary productiveness, by the simple use of appropriate doses of gypsum, without underdraining, blasting, or other extraordinary precautions or costly operations.

The fact above noted, that gypsum will cause the alkali hardpan to soften and crumble, will be found effective in raising to the general level the sunken surface of spots of black alkali, besides gradually rendering it pervious to water even in the depths of the subsoil. The water-tightness of these hardpans is one of the greatest difficulties in the reclamation of such lands; but if gypsum be allowed plenty of time and water, it will frequently correct this trouble without any further effort on the part of the farmer. (E. W. H.)

ANALYSES OF ALKALI.

Leachings of two alkali soils, 2 miles northeast of Amedee, Lassen County, California; sent by Dr. T. R. Grindley. Soils irrigated from an artesian well.

	No. 1.		No. 2.	
Per cent soluble matter in soil		4.29		5.35
Percentage composition of soluble matter—				
Again soluble in water after evaporation		97.99		95.38
Insoluble in water after evaporation		2.01		4.62
		100.00		100.00
Salts permanently soluble—				
Sodium carbonate	22.73		29.86	
Sodium chlorid	41.10	97.99	29.00	95.38
Sodium phosphate	1.58		3.77	
Sodium sulphate, etc.	32.58		32.75	
Insoluble after evaporation—				
Calcium and mag. carb., calcium sulphate, etc.	.74		1.09	
Calcium phosphate	.68	1.42	.57	2.66
Silica		.59		1.96
Total		100.00		100.00
Total phosphoric acid		1.01		1.96

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The above samples doubtless represent a surface layer or crust, and not the soil-mass itself, since an impregnation to the extent of 4 and 5 per cent is incompatible with even the hardiest vegetation. Probably the impregnation does not exceed one eighth or one tenth of the above amounts at the depth of one foot, as has been found to be the case in other portions of the same region. The large proportion of sodium carbonate ("black alkali") in the mixture of salts indicates the need of the use of gypsum for neutralization at all points where alkali now appears, and probably over the entire surface of this kind of soil. About the high fertility of these soils when reclaimed there can be no question, both from the actual experience had and from the composition of the soil of the region as given in a former report (1891–92, p. 26). The large proportion of soluble phosphoric acid shown in the above table should probably have been supplemented by corresponding amounts of potash and saltpeter, which unfortunately were not sought for at the time. The following analysis probably shows an average of the usual proportion of potash present in the alkali of the Honey Lake border.

Leachings of alkali crust, 1½ miles southeast of Amedee, Lassen County, T. 8 N., R. 16 E.; sent by Dr. T. R. Grindley.

Per cent of moisture in crust		9.44
Per cent soluble matter in crust		74.23
Percentage composition of soluble matter—		
Again soluble in water after evaporation		96.209
Insoluble in water after evaporation		.346
Organic matter		3.445
		100.000
Salts permanently soluble—		
Potassium sulphate	10.692	
Sodium sulphate	35.452	
Sodium carbonate	19.721	
Sodium chlorid	29.625	
Sodium phosphate	.719	
		96.209
Insoluble after evaporation—		
Calcium sulphate	.039	
Calcium phosphate	.005	
Ferric phosphate	.072	
Ferric oxid*	.088	
Magnesium carbonate	.110	
		.314
Silica		.032
Organic matter		3.445
Total		100.000
Total phosphoric acid		.347

*Doubtless in combination with humic substances.

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Alkali deposit, from Honey Lake Valley, Lassen County, California; sent by H. A. Lennon, of Amedee.

	Native Salts. Percentage Composition.	100 Parts. Dissolved in Water and recrystallized, will yield—	
		Parts.	Percentage Composition.
Water	22.15		
Sodium carbonate	53.52	143.87	76.25
Sodium bicarbonate	6.47	7.24	3.83
Sodium sulphate (with small amount potassium)	15.55	35.26	18.69
Sodium chlorid	1.92	1.92	1.02
Calcium and magnesium salts	.14	.14	.07
Silica	.25	.25	.14
Borax	Trace.		
Totals	100.00	188.68	100.00

The second and third columns above show what can be obtained from the salts as sent, by dissolving and crystallizing. Thus, 100 pounds of the salts will make 188 of crystallized soda of the percentage composition given in the third column; that is, containing not less than 76 per cent, and possibly as much as 85 per cent, of the carbonate of soda, according to the care exercised in the crystallization. This material is said to occur in considerable quantities in the region.

Alkali from the Wildflower country; sent by Paoli Gypsum Company, of Selma, Fresno County. In the region in which Wildflower Post Office is situated, to westward of Kingsburg and Selma, there is a tract of country about 5 miles wide and 10 miles long, on which alkali salts are seen to a greater or less extent, sometimes continuously over large tracts, sometimes only in spots.

Four samples from different localities were sent, each representing the soil to the depth of 12 inches and the surface layer or crust, in which, by evaporation, the alkali has accumulated. Of these samples, the one least impregnated, No. 1, and the one appearing most strongly impregnated, No. 2, have thus far been examined in detail, the corresponding crust being used for the determination of the ingredients of the alkali, while in the soils only the total quantity was determined. The following table shows the result:

	Wildflower No. 1.		Wildflower No. 2.	
	Soil.	Crust.	Soil.	Crust.
Potassium sulphate	Very little.	Very little.	Very little.	
Sodium sulphate	Little.	14.24	6.33	16.92
Sodium carbonate	Little.		Traces.	47.02
Sodium chlorid	Mainly.	78.66	Chiefly.	35.18
Sodium nitrate	Traces.	6.92	Traces.	.88
		99.82		100.00
Percentage of alkali salts in soil	.075		.167	
Organic matter and chemically combined water	Some.	12.31	Consid'ble	22.28

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It will be seen that these two samples differ very materially in the character of their alkali salts. No. 1 consists chiefly of common salt, with about 14 per cent of Glauber's salt and nearly 7 per cent of Chile saltpeter; while No. 2 contains only half as much common salt, and nearly half of it consists of carbonate of soda, with not quite 1 per cent of Chile saltpeter, and about 17 per cent of Glauber's salt. No. 1, therefore, is strictly a "white alkali," while No. 2 is very "black," and would, in its present condition, be by far the more noxious of the two. Treatment with gypsum, however, would reverse the conditions, and leave No. 2, with about two thirds of Glauber's salt, much milder than No. 1, with a corresponding amount of common salt. Since, however, No. 2 contains more than twice as much of total salts as No. 1, the average condition of the two might be considered about equalized by the gypsum treatment.

The larger proportion of Chile saltpeter in No. 1, while giving promise of long-continued productiveness without fertilization, shows characteristically, as compared with No. 2, the unfavorable influence exerted by carbonate of soda upon nitrification.

The proportion of potash in both these alkali salts is unusually small, but will, in connection with that contained in the soil-mass itself, doubtless suffice for a number of years without replacement. Phosphates are present in both salts in traces only.

Waters from the Duhring tract, five miles southwest of Fresno; sent by W. R. Nutting. On this tract, portions of which are affected by alkali, some experiments were made with reclamation by drainage. Redwood drains were laid at a depth of two feet with a slope toward a natural pond formed by the rise of bottom water since the neighboring lands have been subjected to irrigation. It being found that the bottom and sides of this pond were almost impervious to water as a consequence of the formation of an alkali clay hardpan, a well-hole was dug a few feet from the edge of the pond with a view of draining, it as well as the water from the redwood drains, into a porous substratum.

The water samples represent the state of things after the first irrigation following the underdrainage and digging of the well.

No. 1. Water left standing on the soil after flooding around the well. Sample is turbid, brown in color, and with odor of sulphuretted hydrogen.

No. 2. Water from a well three feet from a pond; after standing over night. It contained 45.5 grains of solid matter per gallon.

No. 3. Pond water in August. On evaporation it was found to contain 629.5 grains of solid matter per gallon.

No. 4. Water flowing from a drain; sample is dark brown in color.

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	No. 1. Surface Water.		No. 2. Drain Water.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	45.61	7.82	174.76	29.92
Soluble in water after evaporation	18.22	3.12	153.68	26.31
Insoluble in water after evaporation	8.82	1.51	8.64	1.50
Organic matter and chemically combined water	18.57	3.19	12.44	2.13
The soluble part consists of—				
Sodium sulphate (Glauber's salt, etc.)	3.88	.66	10.57	2.00
Potassium sulphate			31.31	5.37
Sodium chlorid (common salt)	5.66	.97	83.88	14.33
Sodium carbonate (sal soda)	8.68	1.49	27.92	4.61
The insoluble part consists of—				
Calcium and magnesium carbonates	4.79	.82	8.29	1.42
Calcium sulphate (gypsum)				
Silica	4.03	.69	.35	.06

It will be seen that while the drain water carries by far the largest proportion of soluble salts (nearly 154 grains per gallon against 18 grains in the surface water), the alkali salts contained in it are comparatively "white" when contrasted with those of the surface water. In the latter nearly one half of the soluble salts is carbonate of soda, while the salts of the drain water contain less than one fifth. Whether this is due to local conditions or to the surface soil generally containing more of the carbonate, we can only conjecture.

Another notable difference is shown in the common salt, which forms over one half of the drain-water alkali while less than one seventh in that of the surface water.

The wide differences already alluded to in the composition of the alkali from one and the same tract are thus again illustrated.

As to the pond water, which has probably formed chiefly by the inflow of surface drainage, its intense alkalinity speaks pointedly of the water-tight nature of its bottom and sides, without which such concentration by evaporation could not have occurred. The notable fact that fully 20 per cent of the drain-water alkali is potassium sulphate (a salt worth in the fertilizer trade some 3 cents per pound) illustrates the enormous waste of precious soil ingredients which may be brought about by the leaching of alkali soils.

Alkali crust from the land of Dr. Perrin, Visalia, Tulare County, California; sent by D. G. Overall.

Per cent soluble matter in crust	32.388
Per cent moisture in crust	1.794
Again soluble after evaporation and ignition	29.542
Insoluble after evaporation and ignition	.774
Chemical water and organic matter	2.072
Total	32.388

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Alkali in Crust.

	Percentage Composition.	Per Cent in Crust.
Sodium carbonate (sal soda)	1.25	.370
Sodium chlorid (common salt)	80.55	23.796
Sodium sulphate	10.10	2.982
Potassium sulphate	8.10	2.394
Totals	100.00	29.542

The amount of sal soda ("black alkali") in this crust is so small as to be almost harmless, while the large amount of potash salt renders it valuable to the soil. The amount present in the land cannot be estimated from the above analysis.

Alkali, from a ditch that passes through an "alkali knoll" near Miramonte, Kern County; sent by Geo. A. Raymond. Examination showed it to be almost pure sulphate of soda ("white alkali"), with very little common salt.

Alkali, from near Buena Vista Lake, southwest of Bakersfield, Kern County, California; obtained by leaching sample of soil; sent by J. H. McLaughlin, of Bakersfield.

Sodium chlorid (common salt) in soil	1.280
Sodium carbonate (sal soda) in soil	.053
Sodium sulphate (Glauber's salt) in soil	3.460

Qualitative analysis of this soil shows it to contain high per cents of lime and phosphoric acid.

If the above samples represent properly the soil-mass, such land could not be profitably cultivated without a partial leaching-out of the soluble salts.

Alkali soils, from 7 miles southwest of Bakersfield, Kern County; sent by U. D. Cross, of Berkeley.

Soils.	Sulphate of Soda.	Chlorid of Sodium.	Carbonate of Soda.
Sample No. 1	Considerable	0.015 per cent	Very small amount.
Sample No. 2	Small	0.023 per cent	Minute amount.
Sample No. 3	Considerable	0.122 per cent	Traces.
Sample No. 4	Traces	Traces	Traces.
Sample No. 5	Large	1.500 per cent	Very small amount.
Sample No. 6	Small	0.017 per cent	Minute amount.
Sample No. 7	Large	0.250 per cent	Small amount.
Sample No. 8	Very small	0.012 per cent	Traces.

The above data show that in the region sampled, the nature of the alkali salts is altogether of the milder type of "white alkali," consisting chiefly of Glauber's salt, or sulphate of soda; while the carbonate, or "black alkali," is present in minute proportions only.

Alkali, from Los Angeles; sent by W. J. Woodward.

No. 1, from the land of T. Wiesendanger, 8 miles southeast of Los Angeles, contains a large amount of carbonate of soda ("black alkali"), with considerable chlorid and sulphate of soda (common and Glauber's salts).

No. 2, from the land of R. D. List, 6 miles southwest of Los Angeles,

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contains considerable chlorid and sulphate of soda ("white alkali") and traces only of the carbonate.

In the former case, treatment with gypsum would doubtless be necessary to make the land do its best under cultivation; while in the case of No. 2, gypsum would be of no special avail.

Leachings of samples of soils from Anaheim, Los Angeles County; sent by Frank J. Capitain, of Los Angeles.

	No. 1. Taken at 6 Inches.	No. 2. Taken at 18 Inches.	No. 3. Taken at 36 Inches.
Sodium carbonate in soil	.093	.106	.033
Sodium chlorid in soil	.042	.141	.010
Sodium sulphate in soil	.044	.033	.006
Totals	.179	.280	.049

Qualitative analyses of these soils show Nos. 1 and 2 to contain about the average amount of lime, with phosphoric acid above the average; in No. 3, the lime and phosphoric acid are about the average. The use of gypsum on these soils would doubtless be beneficial, although the amount of alkali salts present is not excessive.

Saline earth, sent by J. M. Fulton, of Reno, Nevada. Its composition is:

Earth and sand	40.2
Soluble salts	27.5
Moisture or water	32.3
	100.0

The soluble portion consists almost wholly of Glauber's salt or sulphate of soda, with small amounts of the sulphates of potash, lime, and magnesia. On leaching the crude mass and evaporating to crystallization, it would yield 62 per cent, or one half its weight, of a good commercial article of Glauber's salt.

Alkali crust from foot of Rubidoux Hills, near Riverside, Riverside County.

Alkali salts are not abundant in the neighborhood of Riverside, the upland being completely exempt from them; and but an insignificant amount is usually found even in the valleys. The analysis of the above salts was therefore made mainly for the purpose of determining the nature of the water-soluble substances leached out of uplands as a clew to their probable needs in fertilization. The Rubidoux being a granite range, like most of those surrounding Riverside, its washings must be considered fairly representative of those of the other ranges, and of the soils formed from them.

The soil from which these salts bloom out is a reddish loam with a base of granitic sand.

Alkali Crust, Rubidoux Hills, Riverside County.

Potassium sulphate	3.20
Sodium sulphate	84.32
Sodium carbonate	.50
Sodium chlorid	5.93
Sodium nitrate	1.11
Organic matter and chemically combined water	4.94
Total	100.00

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The analysis shows this to be a "white alkali," the bulk of it being sulphate of soda or Glauber's salt, together with a little common salt, and a trifling amount of carbonate of soda. The alkali is therefore of a very mild type; and the fact that it contains over 3 per cent of sulphate of potash, and over 1 per cent of Chile saltpeter, but only a trace of phosphoric acid, suggests forcibly that the suggestions heretofore made in regard to fertilization at Riverside, to wit: First of all, to supply the phosphates, nitrogen next, and then lastly potash, the latter being the most abundant of the three important soil ingredients, rest on a solid basis of fact, though originally based only upon conclusions derived from the analysis of the soils; whose potash percentages range near 1 per cent, while phosphoric acid is, in almost all cases, close to the limit of deficiency.

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III. ANALYSES OF WATERS, AND REMARKS ON WATER SUPPLY.

Analyses made by M. E. JAFFA and MARVIN CURTIS.

During the past season there have been about 75 samples of water sent in from various portions of the State for analysis. The majority of these were to be examined only as to their fitness for domestic and irrigation uses, while in a few cases where sewage contamination was feared, a special analysis was made for free and albuminoid ammonia.

A. STREAM AND LAKE WATERS.

Water from Penitentia Creek, Alameda County; sent by J. H. Flickinger, of San José. The sample was turbid and without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.20	2.09
Soluble in water after evaporation	3.10	.53
Insoluble in water after evaporation	6.76	1.16
Organic matter and chemically combined water	2.34	.40
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.70	.12
Sodium chlorid (common salt)	.54	.09
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	4.66	.80
Calcium sulphate (gypsum)		
Silica	2.10	.36

This is an excellent water for both domestic and irrigation purposes.

Water flowing from a tunnel near Santa Barbara; sent by E. S. Sheffield.

"The tunnel has been driven 400 feet into the Santa Ynez Mountains, and the water from it keeps up quite a constant flow at about 4 miner's inches. It begins at the brink and level of a mountain stream flowing usually about 15 inches. Both creek and tunnel cross the formation (which here is tipped up and stands almost vertical) at right angles. The stratification is unbroken and composed of layers or walls of hard sandstone with dense shale beds alternating. Both shale and sandstone are slightly impregnated with sulphur and lime, probably from the waters."

The sample was clear and without odor or taste.

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	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	35.63	6.10
Soluble in water after evaporation	15.48	2.65
Insoluble in water after evaporation	17.81	3.05
Organic matter and chemically combined water	2.34	.40
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	12.94	2.21
Sodium chlorid (common salt)	.68	.12
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	13.72	2.35
Calcium sulphate (gypsum)		
Silica	4.09	.70

While the total amount of mineral salts can hardly be regarded as excessive, yet the proportion of alkali sulphates (Glauber's salt, etc.) is too great to be used continuously for drinking purposes. These salts are too laxative in their nature for weak systems. For irrigation, the water can be safely used, especially on sandy or loamy soils.

Water from Tia Juana River, San Diego County; sent by J. R. Stearns, of Tia Juana. Analysis made by P. W. Tompkins, a student in the Agricultural College.

The water held suspended matter, but was without odor. It had the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	46.58	7.97
Soluble in water after evaporation	28.73	4.92
Insoluble in water after evaporation	8.16	1.39
Organic matter and chemically combined water	9.69	1.66
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	7.76	1.35
Sodium chlorid (common salt)	16.64	2.83
Sodium carbonate (sal soda)	4.33	.74
The insoluble part consists of—		
Calcium and magnesium carbonates	7.70	1.31
Calcium sulphate (gypsum)		
Silica	.46	.08

This water is sufficiently saline in character to make it unpalatable, and also contains quite a large amount of organic matter. But for these it would be unobjectionable for domestic uses. The combined presence of so much common salt and organic matter throws a suspicion on its purity and freedom from contamination.

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Water from bed of San Diego River, California; sent by J. W. Clemens, of San Diego. Residue blackens considerably on heating.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation.	36.50	6.25
Soluble in water after evaporation	8.35	1.43
Insoluble in water after evaporation	16.88	2.89
Organic matter and chemically combined water	8.47	1.45
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.61	.10
Sodium chlorid (common salt)	4.64	.79
Sodium carbonate (sal soda)	3.10	.54
The insoluble part consists of—		
Calcium and magnesium carbonates	16.88	2.89
Calcium sulphate (gypsum)		
Silica	2.80	.48

The total amount of mineral salts in this water is not much above the standard; and as the greater part of this is of the earths (giving to the water a rather "hard" nature) the water can be safely used for nearly all domestic and for irrigation purposes. Boiling or the use of sal soda will remove the hardness.

B. SPRING WATERS.

Spring water from Plumas County; sent by Adolph Ekman, of Oroville. The sample is clear and without odor, but with an alkaline taste and reaction.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	86.58	14.83
Soluble in water after evaporation	43.12	7.39
Insoluble in water after evaporation	43.46	8.44
Organic matter and chemically combined water	Traces.	
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	14.59	2.50
Sodium chlorid (common salt)	2.04	.35
Sodium carbonate (sal soda)	26.49	4.54
The insoluble part consists of—		
Calcium and magnesium carbonates, chiefly	43.16	7.39
Calcium sulphates (gypsum) very small amount		
Silica	.30	.05

The large amount of mineral salts, and especially of the soluble matter, condemns this water for domestic use; and the excessive amount of carbonate of soda is an additional reason for its rejection for irrigation purposes.

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Water of the Piedmont Water Company; drawn from the pipes in the residence of D. R. Rae, of Linda Vista Terrace, Oakland. The sample was clear, tasteless, and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	19.92	3.42
Soluble in water after evaporation	4.97	.85
Insoluble in water after evaporation	10.80	1.85
Organic matter and chemically combined water	4.15	.71
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.59	.62
Sodium chlorid (common salt)	.14	.02
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	8.76	1.50
Calcium sulphate (gypsum)		
Silica	2.04	.35

The water also contains 0.164 parts of free ammonia and 0.110 parts of albuminoid ammonia per million, which show some contamination from organic matters, but this can probably be removed by filtration. The mineral salts are within the limits of potable waters. The hardness due to the earthy carbonates can be obviated by boiling or by addition of a small amount of quicklime, say 5 grains per gallon.

Water from the Samuel Soda Spring, Napa County; sent by J. R. Morris, of Alameda. Sample was clear and odorless. Its composition was:

	Grains per Gallon.
Total residue by evaporation	85.86
Soluble in water after evaporation	40.89
Insoluble in water after evaporation	32.12
Organic matter and chemically combined water	12.85

The soluble part consists chiefly of bicarbonate of soda, with some chlorid and sulphate of soda, and a small amount of sulphate of potash. The insoluble part consists mainly of carbonate of lime and magnesia, with small quantities of gypsum. A spectroscopic examination showed the presence of lithium, strontium, and boracic acid. Free carbonic acid gas was present in considerable quantities.

Mineral spring waters from Alum Rock Park, on San José city reservation, Santa Clara County; from the Park Commissioners.

No. 1, from the soda spring, was clear, alkaline in character, and with a sweetish taste.

No. 2, of the "blue" sulphur spring, has an odor of sulphuretted hydrogen.

No. 3, of the white sulphur spring, has also an odor of sulphuretted hydrogen.

No. 4, a water with a strong saline taste or "salt condiment."

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	No. 1. Soda Spring.	No. 2. Blue Sulphur Spring.	No. 3. White Sulphur Spring.	No. 4. "Salt Condiment."
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Silica	1.21	1.19	1.30	3.52
Potassium sulphate	.83	3.27	3.08	5.88
Potassium bicarbonate	10.57			
Sodium chlorid	126.94	73.68	38.89	146.67
Sodium bicarbonate	267.12	159.45	115.44	25.11
Sodium sulphate		13.68	13.77	116.51
Lithia (with spectroscope)	Slight test.	Slight test.	Very slight test.	Trace.
Magnesium chlorid	.50			
Magnesium sulphate		.39	.31	24.30
Magnesium carbonate	7.45	5.00	7.81	15.45
Calcium carbonate	20.82	19.52	12.98	19.91
Calcium sulphate	.18	.20	1.03	56.39
Calcium phosphate	3.04	1.17	.97	.32
Iron and alumina (carbonates and phosphates)	.35	.49	.29	.58
Boracic acid (with spectroscope)	Well marked test.	Well marked test.	Well marked test.	Well marked test.
Totals	439.01	278.04	195.87	414.64
Free carbonic acid gas, cubic inches per gallon	215.62	174.03	98.50	22.35
Free hydrogen sulphide gas, cubic inches per gallon		5.60	10.31	

The above table proves that these are carbonated saline waters, Nos. 2 and 3 containing also some free hydrogen sulphide gas. While possessing some medicinal properties, the amount of mineral matter found in each is so great, notably so in Nos. 1 and 4, as shown by the totals (439.01 and 414.64, respectively), as to entirely prohibit the adaptability of any of them for either household purposes or irrigation. The strength of these waters in mineral contents will be better appreciated when it is stated that 40 grains per gallon is the extreme limit which, according to Wanklyn, an ordinary drinking water should contain. As regards the medicinal properties, physicians are the proper judges.

Water from the Mountain Spring Water Company's mains, Los Gatos, Santa Clara County; sent by C. M. Merriam, Superintendent. The sample had no odor, and was clear and colorless. Its composition was as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.54	2.15
Soluble in water after evaporation	2.22	.38
Insoluble in water after evaporation	7.93	1.36
Organic matter and chemically combined water	2.39	.41
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.10	.02
Sodium chlorid (common salt)	.27	.04
Sodium carbonate (sal soda)	1.85	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	7.35	1.26
Calcium sulphate (gypsum)		
Silica	.58	.10

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The water is unusually low in mineral ingredients for the Santa Clara Valley, and no fault can be found with it for any use whatever, save that, like all waters of the region, it is somewhat hard.

Another sample of the water sent for examination was clear and tasteless, and contains but 11.7 grains of mineral salts per gallon. Of this amount 4.0 grains is carbonates of lime and magnesia, with a little silica. The remainder consists chiefly of common salt with small amounts of chlorids of calcium and magnesium, and of sulphate of potash. It is an exceptionally pure water, resembling river waters in composition. It contains less than half the average of earthy matters usually found in the well and spring waters of the Coast Ranges, and is of course admirably adapted to all domestic uses.

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Waters from four springs in San Buenaventura, Ventura County, sent by F. Hartmann. The samples were all clear. No. 1 had a light straw color, was slightly alkaline, with a taste and odor of sulphuretted hydrogen. No. 4 had an earthy taste and was slightly alkaline. The others were free from taste or odor. No. 5 is a sample sent at another time.

	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	118.34	20.26	605.14	103.60	723.13	123.80	433.06	72.14	283.82	48.59
Soluble in water after evaporation	115.64	18.60	524.07	89.72	613.43	105.02	291.99	49.70	193.93	33.20
Insoluble in water after evaporation	2.69	.46	35.74	6.12	38.56	6.60	65.42	11.20	60.16	10.30
Organic matter and chemically combined water	7.01	1.20	45.33	7.76	71.14	12.18	65.65	11.24	29.73	5.09
The soluble part consists of—										
Sodium and potassium sulphates (Glauber's salt, etc.)	103.81	17.77	518.92	88.93	602.34	103.12	282.87	48.44	186.09	31.86
Sodium chlorid (common salt)	2.73	.47	2.05	.35	6.14	1.05	1.63	.27	7.22	1.24
Sodium carbonate (sal soda)	2.10	.36	3.10	.44	4.95	.85	7.49	.99	.62	.10
The insoluble part consists of—										
Calcium and magnesium carbonates, etc.	2.22	.38	31.89	5.46	38.21	6.54	64.84	11.10	59.11	10.12
Calcium sulphate (gypsum)										
Silica	.47	.08	3.85	.66	.35	.06	.58	.10	1.05	.18

Considerable Epsom salt was also found in Nos. 1, 2, and 4. The very large amount of mineral salts, and especially of sulphates, in all of these waters, condemns them for all uses, both domestic and irrigation.

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C. COMMON WELL WATERS.

Well water from two wells which are the source of water supply for Marysville; sent by Norman Rideout. One of the wells is 80 feet, and the other 180 feet in depth. The water of the two wells was combined in one sample. On evaporation this yielded 21.6 grains of mineral salts per gallon, an amount within that usually considered safe for domestic uses. An examination for organic impurities gave the following result: Chlorine, 1.80 grains per gallon; free ammonia, 0.013 parts per gallon; albuminoid ammonia, 0.088 parts per million. The water is therefore quite free from sewage contamination, and can be used with safety.

Well water from Placer County; sent by H. H. Bowman. Sample clear and colorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	13.87	2.38
Soluble in water after evaporation	2.78	.48
Insoluble in water after evaporation	8.47	1.45
Organic matter and chemically combined water	2.62	.45
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.53	.26
Sodium chlorid (common salt)	.95	.16
Sodium carbonate (sal soda)	.30	.05
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	4.32	.74
Silica	4.15	.71

The mineral contents of this water are so small that it cannot take rank otherwise than as a good domestic water; rather unusually pure. The gas is nitrogen, one of the constituents of air, and entirely inert.

Well water from Pixley, Tulare County; sent by B. G. Lathrop. The sample was clear and without odor or taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	10.51	1.80
Soluble in water after evaporation	5.84	1.00
Insoluble in water after evaporation	2.10	.36
Organic matter and chemically combined water	2.57	.44
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.07	.35
Sodium chlorid (common salt)	.68	.12
Sodium carbonate (sal soda)	3.09	.53
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	.93	.16
Silica	1.17	.20

The water is exceptionally pure, and, of course, well adapted for all purposes.

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Well water from A. C. Vandivier, of Firebaugh, Merced County. The sample was clear and without odor, but had a salty taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	207.12	35.46
Soluble in water after evaporation	81.54	13.96
Insoluble in water after evaporation	95.09	16.28
Organic matter and chemically combined water	30.49	5.22
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc., some Epsom salts)	76.34	13.07
Sodium chlorid (common salt)	3.96	.68
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	92.99	15.92
Calcium sulphate (gypsum)		
Silica	2.10	.36

For domestic uses this water is too highly charged with mineral salts, and especially of the soluble sulphates (Glauber's and Epsom salts) to be thought of for a moment. For irrigation purposes, though quite free from carbonate of soda (black alkali), there would be a rapid accumulation of salts, which on most soils would soon prove injurious.

Well water from east of Porterville; sent by C. Talbot, of Tulare. The sample was clear and colorless, and had the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	15.77	2.70
Soluble in water after evaporation	8.17	1.40
Insoluble in water after evaporation	5.79	.99
Organic matter and chemically combined water	1.81	.31
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.97	.70
Sodium chlorid (common salt)	1.98	.32
Sodium carbonate (sal soda)	2.22	.38
The insoluble part consists of—		
Calcium and magnesium carbonates	4.50	.77
Calcium sulphate (gypsum)		
Silica	1.29	.22

This water is a good one for all ordinary uses, whether domestic or agricultural. It has no special medicinal qualities.

Well water from a well 300 feet in depth, located in Sec. 5, T. 15 S., R. 13 E., Fresno County; sent by N. C. Briggs, of Hollister. The sample sent was clear, tasteless, and without odor.

	Grains per Gallon.
Total residue by evaporation	176.98
Soluble in water after evaporation	127.92
Insoluble in water after evaporation	31.54
Organic matter and chemically combined water	17.52

The soluble part consists chiefly of common salt with the sulphates of soda and potash and carbonate of soda. The insoluble part comprises the carbonates of lime and magnesia, sulphate of lime, and silica. The amount of mineral salts present renders this water totally unfit for either domestic or irrigation purposes.

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Water from Kern Land Company. Analyzed by W. L. Dunn, of Oakland, student in Agricultural Laboratory.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	71.84	12.30
Soluble in water after evaporation	34.22	5.86
Insoluble in water after evaporation	27.80	4.76
Organic matter and chemically combined water	9.82	1.68
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	29.03	4.96
Sodium chlorid (common salt)	2.72	.46
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	25.94	4.44
Silica	1.86	.32

The water is too heavily charged with mineral matter for most domestic uses; it would act as a purgative upon most persons, if used repeatedly. For irrigation it is also too heavily charged, unless the land were leached at least every other year by long-continued flooding. It contains over eleven times as much alkali salt as Kern River water.

Well water from Happy Valley, Humboldt County; sent by M. R. Jager. The sample was clear and without taste or odor.

	Grains per Gallon.
Total residue by evaporation	2.57
Soluble in water after evaporation	.57
Insoluble in water after evaporation	1.18
Organic matter and chemically combined water	.52
The soluble part consists of—	
Sodium and potassium sulphates (Glauber's salt, etc.), Sodium chlorid (common salt), chiefly, Sodium carbonate (sal soda)	.57
The insoluble part consists of—	
Calcium and magnesium carbonates, Calcium sulphate (gypsum), chiefly	.99
Silica	.19

This water is remarkably pure and free from mineral salts, and can of course be used for almost any purpose.

Well water from Sonoma; sent by Mrs. M. A. Johnson. It is from a well 10 feet deep. The sample was turbid, and with a slightly earthy taste. The sediment consisted almost entirely of ferric oxid, with some silica.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.79	2.19
Soluble in water after evaporation	2.33	.40
Insoluble in water after evaporation	8.24	1.41
Organic matter and chemically combined water	2.22	.38
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.43	.07
Sodium chlorid (common salt)	.04	.01
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonate, chiefly, Calcium sulphate (gypsum), small	2.22	.38
Silica	6.02	1.03

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When filtered this water is very pure, and suitable for all domestic and irrigation purposes.

Well water from East Oakland; sent by F. Bieler. Analyzed by W. L. Dunn, of Oakland, student in Agricultural Laboratory. Sample tasteless and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	27.45	4.70
Soluble in water after evaporation	11.68	2.00
Insoluble in water after evaporation	10.52	1.80
Organic matter and chemically combined water	5.25	.90
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.15	.21
Sodium chlorid (common salt)	6.82	1.16
Sodium carbonate (sal soda)	3.71	.63
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	8.18	1.40
Silica	2.34	.40

Sanitary Analysis.

Total solids	27.450 grains per gallon.
Chlorine	4.160 grains per gallon.
Free ammonia	.032 parts per million.
Albuminoid ammonia	.064 parts per million.
Oxygen consumed by moist combustion	3.500 parts per million.

This water, while very hard, is unobjectionable in other respects for domestic use, and shows no sign of outside contamination.

Well water from well 50 feet deep; sent by Frank Silva, of Pleasanton, Alameda County.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	18.34	3.14
Soluble in water after evaporation	6.54	1.12
Insoluble in water after evaporation	6.83	1.17
Organic matter and chemically combined water	4.97	.85
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.67	.29
Sodium chlorid (common salt)	1.77	.30
Sodium carbonate (sal soda)	3.10	.53
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	5.49	.94
Silica	1.34	.23

The water is sufficiently weak in mineral salts for domestic use; but for irrigation purposes on lands where drainage waters cannot percolate and pass off freely, there would be a slow accumulation of the carbonate of soda, which in a few years would threaten a case of "black alkali."

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Well water from North Berkeley, Alameda County; sample furnished by W. E. Magee. Water clear, colorless, and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	103.62	17.74
Soluble in water after evaporation	63.90	10.94
Insoluble in water after evaporation	14.60	2.50
Organic matter and chemically combined water	25.12	4.30
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	10.27	1.78
Sodium chlorid (common salt)	51.15	8.74
Sodium carbonate (sal soda)	2.48	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	11.50	1.97
Calcium sulphate (gypsum)		
Silica	3.10	.53
Nitrates	Traces	only.

	Parts per Million.
Free ammonia	.040
Albuminoid ammonia	.328
Oxygen consumed by moist combustion	3.150

Residue does not blacken on heating.

This water, which is very hard, is unfit for domestic purposes, owing to its high mineral contents and contamination with organic matter.

Well waters from East Oakland, Alameda County; sent by Wm. Rutherford. Both samples were clear.

	No. 1. Grains per Gallon.	No. 2. Grains per Gallon.
Total residue by evaporation	59.00	391.94
Soluble in water after evaporation	49.76	365.53
Insoluble in water after evaporation	5.73	9.98
Organic matter and chemically combined water	3.51	16.18

The *soluble part* of both waters consists mainly of common salt with small quantities of the sulphates, and traces of bromides, iodides, and borates of soda and potash.

The *insoluble part* comprises chiefly the carbonates of lime and magnesia, with small amounts of gypsum and silica.

The presence of the bromides and iodides may class these waters as medicinal in character, but otherwise the amount of other mineral salts condemns them for domestic uses.

Water from well 13 feet in depth, located on Sec. 21, T. 11, R. 11; sent by C. J. Welch, of East Oakland. The sample was clear, and salty to the taste.

	Grains per Gallon.
Total residue by evaporation	3240.65
Soluble in water after evaporation	3087.03
Insoluble in water after evaporation	28.04
Organic matter and chemically combined water	125.58

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The enormous amount of residue per gallon shown by this analysis is chiefly of common salt, which makes it a natural brine, and, of course, totally unfit for any use except the manufacture of salt.

Well water from the Judson Iron Works, Oakland; sent by P. Wagner. The works are located on the shore of the bay of San Francisco. The sample has no color, taste, nor odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	25.99	4.45
Soluble in water after evaporation	13.67	2.34
Insoluble in water after evaporation	8.23	1.41
Organic matter and chemically combined water	4.09	.70
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	8.46	1.46
Sodium chlorid (common salt)	2.73	.47
Sodium carbonate (sal soda)	2.48	.41
The insoluble part consists of—		
Calcium and magnesium carbonates	7.94	1.36
Calcium sulphate (gypsum)		
Silica	.29	.05

There were also found a trace of free ammonia, 0.036 parts per million of albuminoid ammonia, and 0.600 of oxygen consumed. While practically free from sewage contamination, as well as from direct influx of brackish water, the mineral ingredients are a little above the limits desired for domestic use, though not enough so as to condemn the water.

Water from well in Lorin, Alameda County; sample furnished and analyzed by A. V. Stubenrauch, a student in Agricultural Laboratory. The well is 80 feet deep. The sample was clear and without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	20.44	3.50
Soluble in water after evaporation	6.54	1.12
Insoluble in water after evaporation	8.36	1.43
Organic matter and chemically combined water	5.54	.95
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.32	.57
Sodium chlorid (common salt)	1.36	.23
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	6.78	1.16
Calcium sulphate (gypsum)		
Silica	1.58	.27

A sanitary analysis showed a trace of free ammonia, 0.076 parts per million of albuminoid, 0.920 of oxygen consumed, and 0.830 of chlorine.

The above water is sufficiently pure in every respect for domestic uses. The amount of mineral salts is within the limits of potable water, and especially so as it consists largely of lime and magnesium carbonates.

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Well waters from Jacob Mueller, of Oakland, Alameda County. Each sample was clear and free from odor or taste.

	No. 1.		No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	28.33	4.85	28.20	4.83
Soluble in water after evaporation	10.22	1.75	10.45	1.79
Insoluble in water after evaporation	16.18	2.77	15.77	2.70
Organic matter and chemically combined water	7.30	1.25	6.83	1.17
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	7.89	1.36	8.19	1.41
Sodium chlorid (common salt)	1.09	.18	1.02	.17
Sodium carbonate (sal soda)	1.24	.21	1.24	.21
The insoluble part consists of—				
Calcium and magnesium carbonates Calcium sulphate (gypsum)	8.88	1.52	8.94	1.53
Silica	7.30	1.25	6.83	1.17

The waters are very similar in contents and character, and both may be regarded as fit for domestic uses, though rather high in mineral salts. The hardness due to the earthy carbonates may be corrected by boiling or by the use of a little sal soda or quicklime.

Well waters from the place of Jacob Mueller, of Oakland. One was from an old well 40 feet deep; the other from a well near Peralta and Thirty-sixth Streets, Oakland, 48 feet deep. The sample from the first was clear and colorless, but had an unpleasant odor. The residue from evaporation blackens considerably on heating. The sample from the well 48 feet deep was clear and colorless. The waters had the following composition, respectively:

	Old Well, 40 Feet.		Well 48 Feet.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	88.97	15.23	20.44	3.49
Soluble in water after evaporation	53.04	9.08	8.23	1.40
Insoluble in water after evaporation	16.97	2.93	9.23	1.58
Organic matter and chemically combined water	18.96	3.22	2.98	.51
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	29.29	5.02	3.15	.54
Sodium nitrate, small quantity.				
Sodium chlorid (common salt)	21.28	3.64	1.36	.23
Sodium carbonate (sal soda)	2.47	.42	3.72	.63
The insoluble part consists of—				
Calcium and magnesium carbonates Calcium sulphate (gypsum)	16.27	2.81	6.66	1.14
Silica	.70	.12	2.57	.44

The water of the first is unfit for domestic use from its composition alone, apart from the intrinsic evidence of its septic character afforded by the large contents of common salt and organic matters, which point to sewage contamination. The water of the 48-foot well is quite "hard,"

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but otherwise quite unobjectionable; there is no reason to suspect it of sewage contamination.

Well water from Berkeley, Alameda County; sent by Robert Dugan. The sample was found to contain more than 100 grains of solids per gallon, which renders it entirely unfit for use.

Well water from East Oakland; sent by James Dowling, corner East Fifteenth Street and Thirteenth Avenue; analyzed by W. L. Dunn, of Oakland, student in Agricultural Laboratory. Sample in good condition, without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	41.47	7.10
Soluble in water after evaporation	24.01	4.11
Insoluble in water after evaporation	12.26	2.10
Organic matter and chemically combined water	5.20	.89
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.08	.19
Sodium chlorid (common salt)	20.46	3.50
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	9.40	1.61
Silica	2.86	.49

This water contains a large proportion (nearly one half) of common salt, and is also very hard in character. It must be suspected of contamination, and is unfit for domestic use.

Well water from Haywards, Alameda County; sent by J. J. Booth. The analysis was made by P. W. Tompkins, of San Francisco, a student in the Agricultural College. The sample held suspended matter, had an odor of sulphuretted hydrogen, and a flat, woody taste; also a milky color. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	29.20	5.00
Soluble in water after evaporation	10.17	2.74
Insoluble in water after evaporation	9.98	1.71
Organic matter and chemically combined water	9.05	1.55
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	6.88	1.18
Sodium chlorid (common salt)	.82	.14
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	6.89	1.18
Silica	3.09	.53

The residue blackens on ignition. The water contains rather more mineral matter than is usual in the region, yet not enough to render it medicinal, or objectionable for domestic use. On some persons it might have a slight aperient effect. The sulphur odor is probably connected with the large amount of vegetable matter found; it would be advisable to clean out the well thoroughly, and this would probably disappear.

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Well water from J. W. Strandberg, of De Forrest, Santa Clara County. The sample was clear and had a taste and odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	30.89	5.29
Soluble in water after evaporation	11.09	1.90
Insoluble in water after evaporation	16.64	2.85
Organic matter and chemically combined water	3.16	.54
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	7.25	1.26
Sodium chlorid (common salt)	1.36	.22
Sodium carbonate (sal soda)	2.48	.42
The insoluble part consists of—		
Calcium and magnesium carbonates	14.31	2.45
Calcium sulphate (gypsum)		
Silica	2.33	.40

This is a potable though very hard water, and for other domestic purposes can be improved by boiling and settling, which would remove the hardness due to the earthy carbonates. It is also suitable for irrigation purposes.

Well water from William Pfeffer, of Gubserville, Santa Clara County. Water contains suspended matter, probably clay.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	35.87	6.14
Soluble in water after evaporation	7.00	1.20
Insoluble in water after evaporation	18.77	3.21
Organic matter and chemically combined water	10.10	1.73
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.76	.47
Sodium chlorid (common salt)	1.77	.30
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates	16.65	2.86
Calcium sulphate (gypsum)	.25	.04
Silica	1.87	.32

Residue blackens slightly on heating.

The mineral salts in the above consist largely of the earths, and do not injure the water for irrigation. For domestic uses where such very "hard" water is objectionable the earths can be removed by boiling.

Sanitary analysis of sample of water from well on public school lot at Saratoga, Santa Clara County; sent by James Fablinger, Clerk of Board of School Trustees.

"The well is 40 feet deep, and the source of the water is in a clay soil, near the base of the mountain. In sinking the well a bed of hardpan, or white clay, was passed through; at the base of the mountain the rock is a limestone. About ten rods east of the well is a swale, or bog, and the village cemetery is about 50 or 60 rods above, on a gentle slope. The water-closets of the school-house are about 100 feet away from the well, and complaint has been made that seepage enters the well and produces disease. The well is bricked up on the sides and bottom."

Water slightly turbid. Residue blackens but slightly on heating. A trace of nitrates present.

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Total solids	16.700 grains per gallon.
Chlorine	.250 grains per gallon.
Free ammonia	.011 parts per million.
Albuminoid ammonia	.092 parts per million.
Oxygen consumed	1.200 parts per million.

The water contains rather an unusually small amount of soluble matters of any kind, and the organic part (ammonia, etc.) is so small in amount that there is certainly at present no sewage contamination.

Well water from Cayucos, San Luis Obispo County; sent by Rev. S. Slocombe. The sample was clear, but had a brackish earthy taste and was alkaline in character.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	162.96	27.90
Soluble in water after evaporation	85.69	14.67
Insoluble in water after evaporation	31.13	5.33
Organic matter and chemically combined water	46.14	7.90
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.02	.37
Sodium chlorid (common salt)	81.82	13.98
Sodium carbonate (sal soda)	1.85	.32
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	30.84	5.28
Silica	.29	.05

The water is too highly charged with mineral salts to be used for any domestic or agricultural purpose. The high amount of earthy carbonates present make it a very "hard" water.

Well water from Saticoy, Ventura County; sent by M. T. Wells. The sample was clear and tasteless, but had an odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	169.39	29.00
Soluble in water after evaporation	89.69	14.50
Insoluble in water after evaporation	64.26	11.00
Organic matter and chemically combined water	20.44	3.50
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	72.79	12.57
Sodium chlorid (common salt)	10.91	1.76
Sodium carbonate (sal soda)	.99	.17
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum), chiefly	64.02	10.96
Silica	.24	.04

The large amount of mineral salts in this water renders it totally unfit for either domestic or irrigation purposes.

Water from Piru, Ventura County; sent by Leslie F. Gay. The sample was clear and without taste or odor. It contains but 2.04 grains of mineral salts per gallon, and is of such exceptional purity that a further examination is not necessary.

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Well water from Tres Pinos, San Benito County; sent by Mrs. A. F. Anderson. Sample tasteless, odorless, and colorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	146.36	25.06
Soluble in water after evaporation	126.22	21.61
Insoluble in water after evaporation	11.09	1.90
Organic matter and chemically combined water	9.05	1.55
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	62.99	10.81
Sodium chlorid (common salt)	54.56	9.32
Sodium carbonate (sal soda)	8.67	1.48
The insoluble part consists of—		
Calcium and magnesium carbonates	9.17	1.57
Calcium sulphate (gypsum)		
Silica	1.92	.33

The analysis shows the water to be of a decidedly purgative nature, and contains far too much mineral matter for use for domestic purposes in general.

Well water from Ventura; sent by Jones & Son, druggists. Analyzed by W. L. Dunn, of Oakland, a student in Agricultural Laboratory. Water contains a small quantity of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	82.71	14.16
Soluble in water after evaporation	55.08	9.43
Insoluble in water after evaporation	21.50	3.68
Organic matter and chemically combined water	6.13	1.05
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	49.14	8.43
Sodium chlorid (common salt)	4.09	.69
Sodium carbonate (sal soda)	1.85	.31
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	17.65	3.02
Calcium sulphate (gypsum)		
Silica	3.85	.66

This water has the composition of a great number of well and spring waters in Ventura and Santa Barbara Counties. Its prominent ingredient is Glauber's salt, or sulphate of soda, which is a saline laxative, and there is enough of it in this water to act in that way, and to benefit persons needing it, but entirely too much for domestic use; viz., about five times as much as is found in good well waters. The salts are practically the mixture known as "white alkali."

Well water from Montalvo, Ventura County; sent by O. P. Cook.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	515.82	88.31
Soluble in water after evaporation	246.20	42.15
Insoluble in water after evaporation	168.22	28.80
Organic matter and chemically combined water	101.40	17.36
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	125.57	21.55
Sodium chlorid (common salt)	113.21	19.33
Sodium carbonate (sal soda)	7.42	1.27
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	153.62	26.30
Calcium sulphate (gypsum)		
Silica	14.60	2.50

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This water is far too heavily charged with mineral matter for any but medicinal use as a purgative; stock might drink of it for the salty taste, but it would be very injurious if often repeated. There is no way to reduce the mineral contents to an unobjectionable figure, although the earthy carbonates could be gotten rid of by boiling, or by the use of lime. There would still remain ten times more saline matter than is considered admissible for drinking.

Water from a well 2 miles southwest from the city of Santa Barbara, on the property of Mrs. Adrian, near the Veronica Spring; sent by A. H. Hastie, through Bach, Meese & Co., of San Francisco. The sample is clear, slightly alkaline in character, and with an earthy taste and odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	307.24	52.60
Soluble in water after evaporation	134.58	23.04
Insoluble in water after evaporation	102.57	17.56
Organic matter and chemically combined water	70.09	12.00
The soluble part consists of—		
Sodium sulphate (Glauber's salt)	25.31	4.33
Potassium sulphate, small amount		
Magnesium sulphate (Epsom salts), small amount		
Sodium chlorid (common salt)	104.32	17.86
Sodium carbonate (sal soda)	4.95	.85
The insoluble part consists of—		
Calcium and magnesium carbonates	101.17	17.32
Calcium sulphate (gypsum), chiefly		
Silica	1.40	.24

The amount of mineral salts in this water is by far too great to render its use admissible either for domestic or irrigation purposes. It differs very widely from the Veronica Spring water, whose analysis is given on page 61 of Report of Experiment Stations for 1890–91; the latter has more than seven times the amount of residue, and a very large proportion of Epsom salt, while this has but little of the latter.

Water sent by Philip H. Rice, of Santa Barbara. It contains nearly 41 grains of mineral matter per gallon, being quite double of what is usually found in irrigation waters. Over one half of this amount, however, consists of earthy matters, either unobjectionable or beneficial—lime, magnesia, and silica—that constitute soils. This can be done away with by using the "lime process" of softening hard waters. The rest of the mineral contents—say about 18 grains per gallon—consists of "white alkali" salts, viz., common and Glauber's salts. There is gypsum enough in the water to keep this alkali from becoming "black" under any ordinary conditions. On porous soils the water can probably be safely used for irrigation purposes.

Well water from T. M. Michaels, Palmdale, Los Angeles County.

"This town is situated on the line of the S. P. R. R., just at the foot of the mountains, on the north side of the Sierra Madre range. One mile south of us, just on the edge of the moutains, there is an upheaval of impervious clay—on a very straight line, varying very little from east to west—and is said to extend several hundred miles. This formation makes a natural dam at the foot of the mountains, over which drainage flows at various points, while at others the wet lands are formed. All along the upper side of this line water is close to the surface, while invariably only a few feet distant, on the opposite side of this

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clay bed, water cannot be obtained until a great depth is reached. Realizing the probable importance of this formation in a supply of water, I sank a well on the upper side of this clay bed, and at 80 feet obtained a flowing stream. Is the water suitable for domestic supply and irrigation? If so, other flowing wells can probably be obtained."

The sample was clear, and without taste or odor. Reaction slightly alkaline.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	112.73	19.30
Soluble in water after evaporation		
Insoluble in water after evaporation		
Organic matter and chemically combined water	15.48	2.65
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	44.86	7.68
Sodium chlorid (common salt)	13.64	2.33
Sodium carbonate (sal soda)	2.48	.43
The insoluble part consists of		
Calcium and magnesium carbonates	35.22	6.03
Calcium sulphate (gypsum)		
Silica	1.05	.18

A further analysis showed traces of free ammonia, 0.032 parts per million of albuminoid ammonia, and 0.48 of oxygen consumed.

It is extremely unfortunate for the good of that region that this water, whose supply seems so abundant, should be so totally unfit for domestic use. Though free from any organic contamination, its mineral salts, especially the sulphates of potash and soda, are in too great quantity, and would, if taken constantly, exert a very weakening, laxative effect upon the system. For irrigation upon the sandy lands of that region the water might be used, provided easy drainage facilities were afforded. The accumulation of the salts in the soil would otherwise be rapid and disastrous.

Well waters from the dairy ranch of W. W. Orr, 3 miles from Downey, Los Angeles County; sent by Q. J. Rowley, M.D.

"There have been severe cases of typhoid fever in the neighborhood, and this water is suspected as the cause. The well is 78 feet deep, and has a double iron pipe lining it and supposed to be proof against surface water. The water is raised by a windmill and delivered into a wooden tank, whence it passes through another galvanized iron pipe into a second wooden tank, from which it is piped into the house and grounds. Sample No. 1 was taken directly from the well as delivered by the pump; No. 2 comes from the faucet in the kitchen."

Both samples were clear and without taste or odor.

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	From Well.		From Faucet.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	28.27	4.84	28.56	4.90
Soluble in water after evaporation	10.57	2.81	10.34	1.78
Insoluble in water after evaporation	15.25	2.61	15.54	2.66
Organic matter and chemically combined water	2.45	.42	2.68	.46
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	8.03	1.37	7.80	1.34
Sodium chlorid (common salt)	.68	.12	.68	.12
Sodium carbonate (sal soda)	1.86	.32	1.86	.32
The insoluble part consists of—				
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	13.15	2.25	13.26	2.27
Silica	2.10	.36	2.28	.39

Sanitary Analysis.

	Grains per Gallon.		Parts per Million.		
	Total Solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.
No. 1. Direct from well	28.27	.42	.20	.054	1.04
No. 2. Kitchen faucet	28.56	.42	Trace.	.056	1.08

The prevalence of typhoid fever cannot be attributed to the water, for in both well and tank there is freedom from hurtful contamination.

In mineral salts, also, the amount is not sufficient for injury to the system, especially as so great a proportion consists of earthy carbonates.

Well water from within city limits of Los Angeles. The well is said to be about 400 feet above the center of the city, distant about 2½ miles. Sample sent by L. N. Peck.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	14.02	2.40
Soluble in water after evaporation	4.96	.85
Insoluble in water after evaporation	8.01	1.37
Organic matter and chemically combined water	1.05	.18
The soluble part consists of—		
Sodium and potassium sulphate (Glauber's salt, etc.)	1.00	.18
Sodium chlorid (common salt)	2.72	.46
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	3.34	.57
Silica	4.67	.80

This is a very good water for all domestic uses, both as to the quality and the quantity of its mineral contents.

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Water from Los Angeles; sent by Professor Bunnell. The sample is slightly alkaline, but clear and without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	29.91	5.12
Soluble in water after evaporation	9.99	1.71
Insoluble in water after evaporation	12.45	2.13
Organic matter and chemically combined water	7.47	1.28
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	6.20	1.06
Sodium chlorid (common salt)	.96	.17
Sodium carbonate (sal soda)	2.84	.48
The insoluble part consists of—		
Calcium and magnesium carbonates	7.89	1.35
Calcium sulphate (gypsum)		
Silica	4.56	.78

A further examination showed the presence of the following, in parts per million: free ammonia, 0.05; albuminoid ammonia, 0.076; oxygen consumed, 1.04.

The water is quite free from hurtful organic matters, and although the mineral salts are rather large in amount, yet it could be used for domestic purposes. For irrigation the water is also suitable, save on heavy, ill-drained lands.

Waters from Mission Valley of the San Diego River, 8 miles from the ocean, San Diego County; sent by J. W. Clemens, of San Diego.

Sample No. 1 is from a well, near the dwelling, on a bench of land 30 feet above the level of the alluvial valley. The well is about 35 feet deep and the water rises in a coarse gravel. No. 2 is from a well in the flat, only about 8 feet deep. It has not been used for some time. No. 3 is from the supply pipe in the flat leading from a reservoir supplied by a pump in a well near the river bed.

The samples were all clear and without odor. No. 1 was sweetish to the taste, and Nos. 2 and 3 slightly yellowish in color. Nos. 1 and 2 were slightly alkaline in character.

	No. 1.		No. 2.		No. 3.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	57.94	9.92	30.61	5.24	28.85	4.94
Soluble in water after evaporation	33.88	5.80	16.59	2.84	14.60	2.50
Insoluble in water after evaporation	14.01	2.40	7.78	1.16	9.34	1.60
Organic mater and chemically combined water	10.05	1.72	7.24	1.24	4.91	.84
The soluble part consists of—						
Sodium and potassium sulphates (Glauber's salt, etc.)	6.11	1.06	3.96	.67	11.31	1.94
Sodium chlorid (common salt)	24.55	4.19	2.73	.47	2.05	.45
Sodium carbonate (sal soda)	3.22	.55	9.90	1.70	1.24	.21
The insoluble part consists of—						
Calcium and magnesium carbonates	13.43	2.30	6.55	1.12	8.53	1.46
Calcium sulphate (gypsum)						
Silica	.58	.10	.23	.04	.81	.14

The water of No. 1 is too highly charged with mineral matters to be safely used for any domestic purpose. That of No. 2 might do for

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domestic purposes, but the large amount of carbonate of soda condemns it at once for irrigation. The water of No. 3 contains rather a large amount of the laxative salts, which might affect weak stomachs; but it might be safely used for irrigation on light, well-drained soils.

Well water from San Diego; sent by Mr. A. D. Haight. Analyzed by W. L. Dunn, of Oakland, a student in Agricultural Laboratory. Water clear, colorless, with salty taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	502.56	86.04
Soluble in water after evaporation	332.36	56.90
Insoluble in water after evaporation	66.99	11.47
Organic matter and chemically combined water	103.21	17.67
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	54.37	9.41
Sodium chlorid (common salt)	275.52	47.07
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	60.92	10.43
Calcium sulphate (gypsum)		
Silica	6.07	1.04

The analysis shows that nearly half of the solid matter is common salt, with a small proportion of Glauber's salt. It is essentially a brine, promising no medicinal qualities beyond those of sea water.

Well water from Encinitas, San Diego County; sent by Chas. R. Woodward.

"The well is situated on the mesa, about 40 feet above and one fourth of a mile back from high-water mark. The water was first struck at 70 feet, in a sandy formation, after passing through about 25 feet of a blue rock. The water rises to within 35 feet of the top of the well, and there seems to be a large supply. It is slightly tepid, but perfectly clear when first drawn; but after standing in the open air for a short time becomes cloudy and a metallic-looking scum rises to the top."

The sample sent was clear, colorless, and had a saline taste. The residue from evaporation did not blacken on ignition.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	396.96	67.96
Soluble in water after evaporation	294.46	50.41
Insoluble in water after evaporation	74.06	12.68
Organic matter and chemically combined water	28.44	4.87
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	268.98	46.06
Sodium chlorid (common salt)	23.25	3.97
Sodium carbonate (sal soda)	2.23	.38
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	74.06	12.68
Calcium sulphate (gypsum), chiefly		
Silica		

The water is too strongly charged with salts for any domestic use, or for the supply of cattle; it would weaken them generally. It is also too strong for any use in irrigation, as it would soon convert the land into "alkali" soils of the "white" class.

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Well waters from National City, San Diego County; sent by G. F. Hargis. Well No. 1 is 53 feet deep, and its water is found in a bed of bowlders. Well No. 2 is 47 feet deep, with water in sand. The samples from both wells were clear and without taste or odor.

	Well No. 1.		Well No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	84.28	14.43	101.05	17.30
Soluble in water after evaporation	59.58	10.20	72.08	12.34
Insoluble in water after evaporation	19.74	3.38	17.87	3.06
Organic matter and chemically combined water	4.96	.85	11.10	1.90
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	58.34	9.99	70.48	12.06
Sodium chlorid (common salt)				
Sodium carbonate (sal soda)	1.24	.21	1.60	.28
The insoluble part consists of—				
Calcium and magnesium carbonates	17.23	2.95	12.03	2.06
Calcium sulphate (gypsum)				
Silica	2.51	.43	5.84	1.00

The waters are too high in mineral salts to be fit for domestic purposes. They might do for irrigation on sandy, well-drained soils, where the mineral salts could not accumulate, but are entirely unfit for heavy clay lands.

Water of the Rio Grande, sent by Messrs. Ketelsen & Degetau, of El Paso, Texas. The sample was turbid and fetid, with a brownish flocculent sediment. Its contents per gallon are as follows:

Total residue	34.4 grains.
Insoluble after evaporation	3.5 grains.
Soluble after evaporation	30.9 grains.
The soluble portion contains:	
Common salt	22.6 grains.
Glauber's salt	1.2 grains.
Organic matter	7.1 grains.

This analysis agrees with those since made at the New Mexico Station, showing that both the soils and irrigation waters are nearly if not quite free from carbonate of soda, which together with the porous nature of the soils renders their use for irrigation perfectly admissible.

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D. ARTESIAN WATERS.

Artesian water from a well eight miles southwest of Mendota, Fresno County; sent by Philip Dengler. The well is 480 feet deep. The sample was clear, but with a slight taste and odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	74.07	12.68
Soluble in water after evaporation	64.02	10.96
Insoluble in water after evaporation	7.53	1.29
Organic matter and chemically combined water	2.52	.43
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.; some Epsom salts)	57.23	9.82
Sodium chlorid (common salt)	2.46	.42
Sodium carbonate (sal soda)	4.33	.72
The insoluble part consists of—		
Calcium and magnesium carbonates	3.62	.62
Calcium sulphate (gypsum)		
Silica	3.91	.67

The total of mineral salts in this water is too great to make its domestic use permissible, especially when so large a part consists of laxative Glauber's and Epsom salts. For irrigation purposes, also, this water could serve only in light and well-drained soils.

Artesian water from the S. P. R. R. round-house, Mendota, Fresno County; sent by J. H. Harding. Depth of well, 680 feet. The sample is clear, with taste and odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	75.23	12.88
Soluble in water after evaporation	63.43	10.86
Insoluble in water after evaporation	8.00	1.37
Organic matter and chemically combined water	3.80	.65
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc., some Epsom salt)	54.51	9.34
Sodium chlorid (common salt)	2.73	.46
Sodium carbonate (sal soda)	6.19	1.06
The insoluble part consists of—		
Calcium and magnesium carbonates	3.33	.57
Calcium sulphate (gypsum)		
Silica	4.67	.80

This water is very similar to that from the well of Philip Dengler, 8 miles from Mendota. Its mineral salts are too abundant (especially the Glauber's and Epsom salts) for domestic uses, while its carbonate of soda would doubtless cause a severe case of "black alkali" in the land irrigated with it, unless proper precautions were taken.

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Water from a flowing artesian well, at Midway, Alameda County; sent by Wm. B. Faulkner. The sample was clear and without odor or taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	72.78	12.46
Soluble in water after evaporation	51.99	8.90
Insoluble in water after evaporation	14.01	2.40
Organic matter and chemically combined water	6.78	1.16
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	9.30	1.60
Sodium chlorid (common salt)	26.60	4.54
Sodium carbonate (sal soda)	16.09	2.76
The insoluble part consists of		
Calcium and magnesium carbonates	13.72	2.35
Calcium sulphate (gypsum)		
Silica	.29	.05

The large amount of mineral salts in this water makes it unfit for domestic, or for irrigation purposes on other but light, well-drained land.

Well waters from three artesian wells in Nordhoff, Ventura County; sent by E. F. Baker, of Nordhoff.

Wells Nos. 1 and 2 are only 175 feet apart. The depth of the former is 98 feet, of the latter, 204 feet. The water of the first flows at the surface 11½ gallons per minute, and would rise to the height of 19 feet above the surface of the ground. The water of No. 2 flows 16 gallons per minute, and would rise 35 feet above the surface of the ground. Well No. 3 is 113 feet deep, flows 15 gallons per minute, and is about 300 yards from the other two. The following strata were passed through in sinking Nos. 1 and 2:

Well No. 1.

Black adobe	2 feet.
Red soil	23 feet.
Blue clay	31 feet.
Sand	3 feet.
Sand and fine gravel	6 feet.
Sand and gravel	2 feet.
(At this depth, first flow of water, 10 gallons per minute.)	
Clay	6 feet.
Sand and fine gravel	3 feet.
(At this depth, second flow of water, 10 gallons per minute.)	
Yellow clay	14 feet.
Sand and clay	6 feet.
Sand and fine gravel	2 feet.
(At this depth, third flow of water, 11½ gallons per minute.)	

Well No. 2.

Black adobe	2 feet.
Red soil	20 feet.
Blue clay, with some gravel	24 feet.
(Water, 8 gallons per minute.)	
Blue clay	8 feet.
Sand	2 feet.
Gray and blue clay	13 feet.
Sand and fine gravel	3 feet.
Gray clay	3 feet.
Sand and fine gravel	2 feet.
Red clay	15 feet.
Sand and fine gravel	3 feet.
Red clay	10 feet.
Blue clay	3 feet.
Sand and fine gravel	1 foot.
Blue clay	20 feet.
Sand	6 feet.
Blue clay	49 feet.
Sandy clay	9 feet.
Yellow clay	4 feet.
Sand and gravel	7 feet.
(Water, 11½ gallons per minute.)	

Sanitary Analyses.

	Grains per Gallon.		Parts per Million.		
	Total Solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.
Well No. 1	23.36	.17	.01	.05	.70
Well No. 2	25.70	.42	.05	.05	.90
Well No. 3	22.55	.13	.01	.03	.65

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The character of the mineral salts in these waters was not ascertained, but as the entire amount of total solids in each is within the limits of good potable waters, it is not probable that laxative salts exist to any serious extent. The waters are not contaminated to any extent with organic matters, a result to be anticipated in all deep wells whose water is delivered at the surface through pipes.

Artesian well water from Helena Orchards, Fullerton, Orange County. Sent by L. B. Benchley.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	51.69	8.85
Soluble in water after evaporation	23.95	4.10
Insoluble in water after evaporation	20.73	3.55
Organic matter and chemically combined water	7.01	1.20
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	18.99	3.25
Sodium chlorid (common salt)	2.73	.47
Sodium carbonate (sal soda)	2.23	.38
The insoluble part consists of—		
Calcium and magnesium carbonates, chiefly	18.22	3.12
Calcium sulphate (gypsum)		
Silica	2.51	.43

Residue blackens on heating. The water contains some "white alkali," but can be used without detriment on light porous soil, from which the alkali can be washed out from time to time by flooding. If the soil is not already alkaline, it will take many years to cause injury from this water.

Artesian water from well in Buena Park, Orange County; sent by J. Whitaker. The sample was clear and without taste or odor. The composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	25.35	4.34
Soluble in water after evaporation	10.22	1.75
Insoluble in water after evaporation	10.22	1.75
Organic matter and chemically combined water	4.91	.84
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	8.30	1.42
Sodium chlorid (common salt)	.68	.12
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	9.29	1.59
Calcium sulphate (gypsum)		
Silica	.93	.16

The amount of mineral salts present brings this water within the limits suitable for use, both domestic and irrigation.

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Artesian Waters from Indio, a station of the S. P. R. R., on the border of the Colorado Desert, San Diego County; sent by M. L. Requa, of Oakland. The samples were all clear, tasteless, and odorless.

	New Well.				Reservoir at Spur.		Little Well at Spur.		Wise Well.	
	From Surface.		From Bottom.							
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	10.51	1.80	10.40	1.78	8.76	1.50	9.34	1.60	14.95	2.56
Soluble in water after evaporation	3.86	.66	3.86	.66	6.72	1.15	6.31	1.08	5.37	.92
Insoluble in water after evaporation	6.42	1.10	6.31	1.08	1.22	.21	2.33	.40	5.72	.98
Organic matter and chemically combined water	.23	.04	.23	.04	.82	.14	.70	.12	3.86	.66
The soluble part consists of—										
Sodium and potassium sulphates (Glauber's salt, etc.)	2.48	.43	2.48	.43	2.90	.49	3.69	.63	2.20	.38
Sodium chlorid (common salt)	.14	.02	.14	.02	.11	.02	.14	.02	.07	.01
Sodium carbonate (sal soda)	1.24	.21	1.24	.21	3.71	.64	2.48	.43	3.10	.53
The insoluble part consists of—										
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	4.09	.70	3.98	.68	.64	.11	1.75	.30	4.55	.78
Silica	2.33	.40	2.33	.40	.58	.10	.58	.10	1.17	.20

The waters bear a close resemblance to each other, both in purity and in the proportion of each mineral salt, thus indicating a common source, in the mountains bordering the desert. The waters are suitable for all domestic and irrigation purposes, and considering the region of occurrence, are remarkable for the small proportion of saline ingredients.

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THE CIENEGAS OF SOUTHERN CALIFORNIA.*

By E. W. HILGARD.

A *cienega*, in the parlance of the native Californian, is a limited area showing a growth of water-loving plants, appearing sporadically in otherwise arid surroundings—usually hillsides or valley margins—and occasionally giving rise to flowing springs. The economic importance lately attained by these cienegas as sources of irrigation water by the aid of artesian borings, and some peculiarities of structure upon which their occurrence in that particular region depends, seems to justify at least a brief presentation of the facts in this report.

San Antonio Creek Cienegas.—A simple and typical case in point is presented, for instance, by San Antonio Creek, a stream issuing from a cañon in the Sierra Madre Mountains, near the town of, Pomona, in the San Bernardino Valley, Los Angeles County. It is near the present divide between the adjacent drainage basins of the San Gabriel River on the west and the Santa Ana River on the east. Though a small stream, carrying only from 700 to 800 miner's inches of water in summer time, it has formed in front of its exit from the cañon a debris-cone or "fan," having a radius of 7 or 8 miles, of which the apex, near the cañon mouth, is between 400 or 500 feet above its base. On the slopes of this fan, as well as near its base, there appear numerous cienegas, some less than an acre in area, while others range up to twenty acres and over. In some of these, large sycamore trees are the only unusual indication amid the "bee pastures" of white sage, cactus, and other plants characteristic of the dry mesas of the south. In others, there is added the willow and clumps of "tule" (cat-tail) and other swamp plants. From some, springs issue naturally; in all, shallow dug wells find water; in many of them, artesian bores have been made with good success. The deposits penetrated in these bores are, of course, such as may be expected in a debris-fan; but they vary so quickly and completely in wells only a short distance apart as to show that the ancient portions of the fan have been formed under a régime exactly like the present—namely, an alternation of very coarse deposits of gravel and large cobbles, such as are now carried by the stream during the torrential floods to which the high ranges are subject, with fine silt and even clay, which are practically impervious to water. The abrupt diminution of velocity on emergence from the cañon results in the quick accumulation of cobble ridges or "kames," which sometimes change the main channel within a few hours to a totally different direction. It is obvious that in past times such changes of channel have thrown the water of the creek from one drainage basin to the other; at present it discharges toward the Santa Ana basin, but unless artificially prevented, there is no reason why it may not some time revert to the San Gabriel watershed. If we imagine the structure that must result from such a mode of accumulation of a debris-fan, the sporadic appearance and peculiar localization of the cienegas (being the points at which the water fed into the cone at the mouth of the cañon is forced near to the surface either by a cross ridge or by the termination of a water-bearing cobble-bed, underlain by an impervious layer) are easy to understand. But it is also obvious that the continued supply of water from the stream into the various old

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channels of the debris-cone must depend upon the maintenance of the open gravel surface at the apex of the cone. When this is wholly or partially closed, whether by natural or artificial processes, then, the source of supply being stopped, the springs or artesian wells dependent upon it must diminish or cease to flow. Such variations and stoppages have already been experienced at several points, and as they may prove very costly, if not disastrous, to heavy investments already made, it is quite important that the need of keeping the area of infiltration open for the winter floods should be fully understood by the populations concerned. When this is attended to, it is obvious that we have here natural storage reservoirs for flood waters, annually replenished and likely to be fully refilled each season, no matter how heavy may have been the drafts made upon them during the preceding irrigation season.

Santa Ana and Mill Creek Cienegas.—The most extensive example of debris-fan storage of flood waters thus far known to me occurs in the upper San Bernardino Valley, at the head of which two large streams—the Santa Ana River and Mill Creek—emerge from narrow cañons, at whose outlets there are truly phenomenal accumulations of huge bowlders, which in time of flood are tossed about by the torrents with a thundering noise, sometimes audible miles away. Here are many square miles of open cobble surface, into which flood waters can be and are absorbed with the greatest ease, although in the usual channels of the summer flow the bottom is made sensibly waterproof by finer sediments. Costly tunnels have been driven through these cobble-beds, under the impression that large amounts of water could be thus collected; but while the constant drip proves the perviousness and absorbent nature of the deposit, that very circumstance prevents the gathering-together of any very large supply of water in the relatively insignificant areas of the artificial drifts.

From the head of the debris-fan of Mill Creek to its base, near the town of San Bernardino, the distance is between 12 and 14 miles, according to the initial point chosen; the fall of the surface within the same distance is between 600 and 700 feet. The average width of the valley is about 10 miles, and artesian borings have shown the gravel and cobbles to be nearly a thousand feet in thickness within a mile of the southeastern edge. This enormous gravel mass, filled with water from the floods of the two streams, forms a natural reservoir of such magnitude that the drafts thus far made upon it by the numerous boreholes sunk in the lower valley have failed to show any such degree of mutual interdependence as is usually observed in wells situated short distances apart—a fact which I have ascertained by experimental measurements made under proper conditions. This relative independence of the flow of contiguous wells also indicates that the water-bearing stratum consists of gravel so large and so open that the water-mass may be considered as exerting its pressure rather freely in all directions; yet on reopening a closed well there always exists a material accumulation of pressure, which takes several hours to recede to its normal amount.

Besides the artificial outlets mentioned, however, there is a number of *natural* outlets on the slope of this great gravel reservoir. The most conspicuous is the source of Warm Creek, the stream which has been appropriated for the purpose of irrigating the well-known colony of Riverside. Warm Creek has no visible connection with any of the streams that descend from the Sierra Madre; it rises in the valley itself, fully 3 miles

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away from the foot of the range. There is no obvious reason for its being there, but the water gathers from little rills and ditches within a space of about a quarter of a mile, acquiring within that distance nearly its full volume of from 2,000 to 2,500 inches during the dry season. At other points, also, "artesian" springs rise with considerable force and volume; and in the immediate flood-plain of the Santa Ana River, rivulets gather at many points on the margins, at the foot of the bluff some 7 or 8 feet above the river channel, and flow toward the latter to increase the volume of the stream. It thus happens that "the entire flow of the Santa Ana River" has been appropriated at at least three different points, each appropriator receiving a good flow; and that in the absence of any obvious important additions from incoming streams. As may be supposed, boreholes sunk in this region of spontaneous flows encounter at very small depths (from 120 to 150 feet) very copious flows of artesian water, in cobble-beds; while near the border of the valley not only is a greater depth required and the outflow less, but the materials penetrated are much finer.

Since the terraces of reddish loam that border the foot of the Sierra Madre from the head of the valley to the San Gabriel River indicate plainly that the subdivision of the valley into two drainage basins is a comparatively recent event, it does not seem improbable that the artesian reserve referred to might be tapped by deep borings much farther westward than has heretofore been attempted; perhaps within easy reach of the city of Los Angeles.

Temescal Valley Cienega.—A very striking exemplification of the origin of cienegas exists in the valley of Temescal Creek, one of the southern affluents of the Santa Ana River, in San Bernardino County. This creek is really the natural continuation of the San Jacinto River, of San Diego County; but an intervening lake basin (Lake Elsinore) prevents actual flow from the latter stream to the Temescal Valley, save in seasons of extraordinary rainfall. Its water is supplied almost entirely from the cañons of the Santa Ana Mountains, which have a rather copious rainfall in their higher portions. At the head of the valley there is a small lake (Lee's Lake) which, with no visible *in*flow, nevertheless has at its lower end a steady *out*flow of about 400 miner's inches of water during the dry season, thus forming part of the water supply of the South Riverside Colony. Examination shows that the lake is fed entirely by a series of springs, or rather an almost continuous ooze, from the enormous masses of granitic and other debris that have accumulated in front of the two uppermost cañons of the Temescal Valley, and which reach entirely across the valley to the foot of the (Temescal) range opposite. These debris masses are so porous that actual surface flow very rarely occurs, and no well-defined bed for a stream exists save where, close to the lake basin, the materials are relatively fine. Evidently the main body of the rainfall gathered into these cañons is stored in the coarser portions of the debris-fans above.

Below this lake basin the Temescal Valley is divided lengthwise by a series of low ridges formed of materials mostly impervious to water, of tertiary age. In front of the cañons of this lower portion of the valley similar great debris masses have accumulated, also; but since the impervious ridges mentioned prevent the outflow of water save during actual freshets (when small streams pass through gaps in the ridges), extensive cienegas have been formed between the valley ridges and the foot of the

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Santa Ana range. In these, as in the upper San Bernardino Valley, "artesian" springs rise at many points, and vegetation remains bright green all summer. Borings thus far made have developed a very copious artesian flow of nearly 600 miner's inches, which can doubtless be materially increased; and this, with the flow from the lake above, constitutes the water supply for the colonies below.

Importance of Cienegas as Sources of Water Supply.—These examples, which could be greatly multiplied, show sufficiently both the nature and origin of the cienegas, and also their practical importance as sources of water supply, which calls for a more careful survey of their extent of occurrence than has heretofore been made. While they do not render the establishment of artificial storage reservoirs superfluous, they do supplement them locally to a very material extent, rendering it possible to occupy for agriculture large areas that otherwise would have remained arid for many years to come. But there arises the question as to the geographical limits within which these natural storage reservoirs may reasonably be sought, for it is notorious that they are not usually found, and the name and idea of the cienega is not generally known, in the northern portions of California.

The essential condition of cienega-formation is manifestly the opportunity for the abundant formation of deposits of exceptionally coarse and pervious gravel and cobbles near the points where the cañons emerge from the mountains. This, again, is necessarily conditioned upon the occasional occurrence of violent, torrential rainfall in the mountains, alternating with periods when quiet deposition allows of the formation of water-shedding layers. Another condition appears to be the ready weathering of the parent rocks into rounded forms, by which close packing is prevented, so that abundant interspaces are permanently maintained.

Both conditions are fulfilled to an unusual extent in the granitic ranges of Southern California. The rock is rather easily disintegrated, first into larger and then into smaller rounded masses, from which large quantities of very coarse angular sand have been detached, and which continue to disintegrate rapidly when exposed to the air, but are relatively stable when submerged in the debris mass, and so maintain porosity. Such granitic or granitoid material forms the main body of all the larger cienegas I have examined in Southern California; and the remarkably large proportion of potash contained in their waters in consequence is of no small economic importance.

It is therefore reasonable to presume, and it seems *a priori* probable, that a concurrence of the two conditions, climatic and petrographic, is requisite for the formation of cienegas upon a practically useful scale; and the extent to which this concurrence actually exists, geographically, is a question of no little practical interest.

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IV. ANALYSES OF ROCKS, CLAYS, MARLS, ETC.

Marl and clay rock, from Wm. Bowring, San Dimas, Los Angeles County. The marl contains 22.9 per cent of carbonate of lime; and the clay rock, 0.50 per cent of phosphoric acid. While the latter is comparatively rich in phosphates, yet it is not sufficiently so to be of commercial value when transportation is expensive.

Limestone, from San Jacinto, San Diego County; sent by F. R. Haas.

	Per Cent.
Carbonate of lime	72.40
Silica	27.50
Phosphate of lime	.10
	100.00

This is but an ordinary limestone, with too much silica for the production of first-grade lime.

Calcareous rock, sent by Dr. H. Fine, of East Oakland, for the determination of phosphoric acid. It was found to contain nearly one half of 1 per cent (0.47), which is not sufficient to make the rock of any value as a source for that acid.

Cement from Mexico. Analysis was made at request of the College of Mechanics, University of California.

	Per Cent.
Lime	60.14
Silica (soluble in carbonate of soda)	21.33
Sand	1.53
Alumina	6.49
Ferric oxid	4.50
Magnesia	1.48
Potash	.80
Soda	.70
Sulphuric acid	1.02
Phosphoric acid	.14
Carbonic acid	1.12
Water	.17
	99.42

This is a very good cement, the lime and silica, as the basis, being in proper proportions. Its composition compares well with the best cements of the East and of France. It should be very durable, for it is claimed that any cement having less than 40 per cent of lime, magnesia, and alumina would soon yield to the weather, though hardening quickly.

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Peat, two samples, from Mowry's Station, Alameda County; sent by Carnall-Hopkins Co., San Francisco. The air-dried substance contains:

	No. 1.	No. 2.
Water	17.44	17.65
Volatile matter	67.16	73.26
Ash	15.40	9.09
Totals	100.00	100.00
Phosphoric acid in ash	2.64	4.00
Phosphoric acid in peat	.41	.36
Sodium carbonate in ash	.30	3.63
Sodium carbonate in peat	.04	.31
Water in freshly-dug peat	39.98	78.41

Such peats usually contain about 2 to 3 per cent of nitrogen, which, however, cannot be counted upon as effective in fertilization. While thus the amount of fertilizing ingredients in the substance is not enough to entitle it to be used directly, by itself, it is an excellent material for composting, bedding of cattle, etc., as an absorbent. It is also of fair quality as a fuel.

Borate of lime, sent by C. C. Merrill, of Riverside. This, as determined by Mr. Palache of the Mineral Laboratory, is pandermite, an almost pure hydrated lime borate. The locality in which it was found is not given.

Brine, from Antelope Crystal Salt Works, Colusa County. It has the following composition, in grains per gallon:

Chlorid of sodium (common salt)	1,297.31
Chlorid of magnesium	332.36
Chlorid of calcium	2,191.59
Sulphate of lime	56.66
Sulphate of magnesia	Trace.
Silica	Trace.

Specimens Sent for Examination or Identification.

Magnetic iron ore.....by J. A. Clark, of Bakersfield, Kern County.
Quartz.....by Mrs. Rodgriss, of Mountain View, Santa Clara County.
Iron pyrites.....by Mrs. Rodgriss, of Mountain View, Santa Clara County.
Selenite.....by F. A. Connelly, of Bishop, Inyo County.
Infusorial earth.....by F. A. Connelly, of Bishop, Inyo County.
Micaceous soil.....by F. A. Connelly, of Bishop, Inyo County.
Talcose rocks (3 specimens).....by J. S. Hilton, of Porterville.
Pyritous rocks.....by R. Stevens, of Sisson.
Volcanic glass.....by Chamber of Commerce, Los Angeles.
Gypsum.....by William Owen, of Santa Barbara.
Volcanic ash.....by E. Roebuck, of Gila Bend.
Calcite.....by J. A. Lytle, of Tulare.
Volcanic ash.....by J. H. Beaulien, of South Riverside.
Quartz.....by Mrs. Fannie Goodman, of Outing, Riverside County.
Tourmaline crystal.....by Mrs. Fannie Goodman, of Outing, Riverside County.
Actinolite.....by Mrs. Fannie Goodman, of Outing, Riverside County.
Pyritous quartz.....by John Eslick, of Eureka.
Talc.....by N. E. Beckwith, of Los Gatos, Santa Clara County.
Steatite, of San Jacinto Mountains.....by H. F. Whalen, of Riverside.
Calc spar.....by Charles A. Raber, of San Bernardino.
Limestone.....by Charles A. Raber, of San Bernardino.
Hematite.....by Charles A. Raber, of San Bernardino.
Jaspery quartz.....by Charles A. Raber, of San Bernardino.
Galena.....by D. W. Osborne, of Winchester.
Greenstone.....by Thomas Dickenson, of Yager, Humboldt County.
Quartz debris, cemented.....by Mrs. Clesham, of Jamul, San Diego County.
Greenstone.....by H. J. Wibel, of Riverside.
Calcite crystal.....by J. N. Ross, of Fresno.
Halloisite (clay).....by T. C. Willis, of Los Angeles.

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Pyritous sand.....by John Winchester, of Cahto, Mendocino County.
Red ochre.....by John Winchester, of Cahto, Mendocino County.
Black rock—powder.....by John Winchester, of Cahto, Mendocino County.
Yellow ochre.....by John Winchester, of Cahto, Mendocino County.
Steatite.....by W. J. Richardson, of Letcher, Fresno County.
Volcanic ash.....by Addison Rucker, of Willits, Mendocino County.
Magnesian slate.....by Charles A. Raber, of Riverside.
Calcite.....by Rev. W. B. Cullen, of Glendora, Los Angeles County.
Black sand.....by W. J. Evans, of Ruby, Siskiyou County.
Copper ore.....by E. J. Langlos, of Moro, San Luis Obispo County.
Kaolinite.....by Andrew Martin, of Carpenteria, Santa Barbara County.
Clay.....by William Boving, of San Dimas, Los Angeles County.
Clay.....by Chaffee & Bonestel, of Ventura.
Clays (8 specimens).....by — Stevens, of Ione, Amador County.
Clay.....by J. T. Dempsey, of Smartsville, Yuba County.
Clays (2 specimens).....by A. G. Platt, of Rancho del Valle, Alameda County.
Asphaltic clay.....by F. Hartmann, of San Buenaventura, Ventura County.
Clay.....by C. F. Harkrader, of Arbuckle, Colusa County.
Chalk.....by West Side Fruit Growers' Association, Santa Clara.
Shell marl.....by E. Hornbeck, of Stuart, Santa Barbara County.
Lime carbonate.....by G. F. Foster, of Antioch, Contra Costa County.
Marl (2 specimens).....by K. H. Dorsey, of Spadra.
Shell marl.....by M. T. Clark, near Del Mar, San Diego County.
Calcareous marl.....by J. W. Reese, of Fresno.
Yellow ochre.....by J. W. Crittenden, of South Riverside.
Infusorial earth.....by J. A. Mathis, of Santa Barbara.
Sandstone.....by J. A. Mathis, of Santa Barbara.
Black sand.....by Horace Metcalf, of Point Loma, San Diego County.
Bone meal.....by J. Footell, of Florin.
Cotton-seed meal.....by — McLaren, of San Francisco.
Glauber's and common salts.....by Dr. E. Aiken, of Los Angeles.
Bone meal.....by H. E. Phelps, of Ontario.
Peat.....by J. P. Raymond, of Black Diamond, Contra Costa County.
Egg albumen.....by — Beringer, of St. Helena.
Glauber's salt.....by Harry W. McCray, of Bakersfield.

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V. FERTILIZERS AND GYPSUM.

Commercial fertilizer, sent by Edward Berwick of Monterey. The sample as received has the following composition:

Nitrogen—		
As ammonia ready formed	.28	
As nitrates	1.90	
Organic	13.15	
Total		15.33
Calculated as ammonia	18.61	
Phosphoric acid—		
Soluble in water	.07	
Reverted	7.22	
Available	7.29	
Insoluble	14.48	
Total		21.77
Potash		.51

Natural fertilizers (4 samples), from F. W. Fowler, South Riverside. No. 1 has a crystalline appearance; gypsum flakes well marked. No. 2, in the form of a white powder. No. 3, a greenish-gray earth lump, coated and streaked with salt. No. 4, a coarse white powder.

	No. 1.	No. 2.	No. 3.	No. 4.
Silica	1.07	9.09	28.18	19.08
Sulphate of lime (gypsum)	31.61	55.15	3.54	11.33
Carbonate of lime	67.32	45.76	35.64	11.63
Phosphate of lime			1.96	2.53
Chlorid of calcium			1.60	
Chlorid of sodium			28.09	.96
Carbonate of soda			.99	1.19
Sulphate of soda				53.28
Total	100.00	100.00	100.00	100.00

The first and second samples contain fair amounts of gypsum, but only for local use; not rich enough to make them of commercial value. The third sample is made up chiefly of lime carbonate and common salt, while the last is composed chiefly of Glauber's salt (sulphate of soda), with some gypsum and lime carbonate.

Fertilizer, from Dwight L. Wilbur, of Riverside.

Moisture		14.64
Nitrogen—		
As ammonia	.70	
Organic ammonia	6.81	
Total as ammonia		7.51
As nitrates	None.	
Phosphoric acid—		
Water-soluble	.69	
Reverted	4.43	
Total available	5.12	
Insoluble	4.60	
Total		9.72
Potash		.07

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Guano fertilizer, from J. W. Kishler, of Riverside. Analysis made by P. W. Tompkins, of San Francisco, student in Agricultural Laboratory.

Moisture		18.55
Nitrogen—		
As ammonia	5.77	
Organic ammonia	3.15	
Total as ammonia		8.92
As nitrates	Trace.	
Phosphoric acid—		
Water-soluble	6.87	
Reverted	6.37	
Total available	13.24	
Insoluble	1.75	
Total		14.99
Potash		3.26

Bone dust, from Calcutta, India; sent by Parrot & Co., of San Francisco.

	No. 1.	No. 2.
Phosphoric acid	24.86	27.75

The average percentage of phosphoric acid is about 30 in pure bone-meal, and hence the above samples are somewhat below the purity mark. No. 2, however, may be regarded as very good and worthy of importation.

Gypsum, from John H. Gray, of San Francisco. A white translucent piece, very pure, quite free from carbonate of lime. It was sent by the Central Milling Company, of Hollister, and said to be found in Bitterwater Valley, San Benito County.

Gypsum, sent by Mr. R. Rickard, of Berkeley.

	Per Cent.
Gypsum	95.63
Carbonate of lime	2.03
Sand, etc.	2.34
	100.00

This is a very good specimen of gypsum, of a high degree of purity.

Another specimen, a white powder, was found to contain 95 per cent of gypsum.

Gypsum, from Herman Mier, of Sacramento. The samples comprise: No. 1, a white granular gypsum, very pure, though having some carbonate of lime; No. 2, a selenite crystal; and No. 3, a nodule of limestone in concentric layers. No. 1 is the most valuable, and is said to occur in large quantity at Coalinga, Fresno County.

Gypsum, from Herman Mier, of Sacramento; analyzed by J. W. Mills, of Marysville, a student in Agricultural Laboratory.

	Per Cent.
Gypsum	89.94
Carbonate of lime	3.16
Iron and alumina	Traces.
Sand, etc.	3.00
Moisture and loss	3.90
Total	100.00

This is a very good gypsum, and nearly as pure as can be obtained in the market. Commercial samples sometimes reach a purity of 95 per cent, but are more generally below that.

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Gypsum, from San Benito County; sent by E. S. Jones, of San José, Santa Clara County; analyzed by P. W. Tompkins. No. 1 is a massive variety of very pure gypsum; Nos. 2, 3, and 4 are whitish gypseous powders, No. 3 being the most impure. The composition of Nos. 2 and 4 is as follows:

	No. 2.	No. 4.
Gypsum	79.48	83.88
Sand, silica, etc.	8.06	9.67
Carbonate of lime (6 to 8 per cent)	12.46	4.00
Other impurities		2.45
	100.00	100.00

The above samples of gypsum are quite within the limits of usual commercial qualities of "land-plaster," although of course the cost of transporting say 20 per cent of inert matter will prevent its shipment to long distances. For the latter purpose, the grinding of the hard rock (No. 1) which is always high in the ninety per cents, would be the proper thing; but the readiness with which the lower grade can be prepared for use may offset in the reduction of cost the difference in freights.

Gypsum, two samples; sent by Louis Bravermann, of San Francisco. An analysis gave the following composition:

	No. 1.	No. 2.
Gypsum	40.75	76.14
Sand	47.34	16.86
Other impurities	11.91	7.00
	100.00	100.00

The first sample of gypsum can be used by taking correspondingly larger quantity, but, of course, the price should be correspondingly lower than that of material double the purity.

The second, which is from near Mendota, is a very fair grade of gypsum, though not up to the standard of much that is in the market, and which contains as much as 90 per cent of gypsum.

Gypsum and *gypseous clays*, sent by A. C. Vandivier, of Firebaughs, Fresno County. They were taken from the foothills west of the valley. The result of the examination is as follows:

No. 1—Lead-colored clay, with 7.2 per cent of gypsum.
No. 2—Yellowish clay, with 4.0 per cent of gypsum.
No. 3—Deep purple clay, with 4.2 per cent of gypsum.
No. 4—Light gray clay, with very little gypsum.
No. 5—Light-colored sand, with 2.1 per cent of gypsum particles.
No. 6—Purple clay, with very little gypsum.
No. 7—Fragments of purple claystone.
No. 8—Massive purple claystone.
No. 9—Gypseous clay, with 29.4 per cent of gypsum.
No. 10—Whitish sandstone.

In No. 9 only is there sufficient gypsum to make its application to the land worthy of any expense, and then only very near the locality. Fully three times as much of this as of the good commercial article would have to be applied.

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Gypseous marl, from J. W. Reese, of Fresno; analysis made by P. W. Tompkins.

	Per Cent.
Silica, sand, etc.	17.39
Gypsum	1.28
Carbonate of lime	81.33
	100.00

It also contains one tenth of one per cent of phosphoric acid. The sample cannot be called gypsum, but rather a slightly gypseous marl, and of no special value.

Gypsum and clays, sent by P. Dengler, of White's Bridge, Fresno County. One lot, from 12 miles west of Los Baños, comprised a sheet of impure gypsum about an inch in thickness; a sample of grayish clay, containing a little sulphate of magnesia; and a red, sandy earth holding much sulphate of magnesia and some carbonate of lime.

Another lot, from 20 miles north of the first, comprised large columnar crystals of gypsum; a light gray earth, with 4.2 per cent of gypsum; and a red ochreous earth from beneath the gypsum on the hillside. A white alkaline earth near the latter contained 23 per cent of sulphate of magnesia, and 0.8 per cent of gypsum.

Gypsum, from Coast Range foothills west of Tulare; sent by C. Lazenby, of Tulare, and E. D. Jones, of Dudley. The sample is quite pure, containing 94.2 of gypsum and 5.8 of insoluble matter. There are only traces of carbonate of lime. With good transportation facilities and an abundant supply of the mineral, it should be highly remunerative.

Gypsum, from John Roth, of Woodville, Tulare County. The specimen is from the west side of Tulare Lake. It is in the form of a light-colored hard rock, with much carbonate of lime. The percentage of gypsum is 86, which brings it into the class of profitably working deposits if in sufficient quantity and near transportation facilities.

Gypsum, from W. T. Hall, of Visalia; analyzed by Miss H. B. Perkins, of Alameda, a student in the Agricultural Laboratory. The sample is in the form of a powder, and has the following composition: Gypsum, 84.53 per cent; sand and other impurities, 11.98 per cent; moisture, 3.45 per cent. This is very fair gypsum, though not as rich as some found in the market, which run as high as 95 per cent. In application, 560 pounds of this must be used for every 500 pounds of the latter.

Gypsum, sent by Mrs. Nellie Boyd, of Fresno. It has the following composition:

Gypsum	40.73
Sand	47.34
Other impurities	11.91
	100.00

This is rather a low-grade article, and with 90 per cent gypsum selling at say $10 per ton, should be proportionately low in price.

Gypsum, from the Alpine Plaster Company, of Los Angeles. The sample is in the form of a creamy-white powder, and on analysis was found to be composed of 78.5 per cent of gypsum, 15.5 per cent of carbonate of lime, and 6 per cent of insoluble matter. The percentage of gypsum is rather low for a commercial article.

Gypsum, from Antelope Valley, Los Angeles County; sent by Geo. H. Delp, of Los Angeles. It is said to form an almost inexhaustible bed

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near the railroad at Harold Station, same county. The sample is whitish, and contains a little carbonate of lime. The percentage of gypsum is a little more than 95 per cent, which makes it quite valuable.

Gypsum, from Fowler & Smith, of Los Angeles. Sample No. 1 is whitish, with hard lumps of the mineral. It contains only 36.8 per cent of gypsum, the rest being chiefly insoluble matter; it is therefore suitable for local use only. Sample No. 2 contains fragments of the hard country rock, which could be removed by sieve. The sample then contains 68 per cent of gypsum, 20 per cent of insoluble residue, and the rest of other acid-soluble substances not determined.

Gypsum, from Rev. W. B. Cullen, of Glendora, Los Angeles County. A solid piece, quite white and pure, found in a stratum three feet in thickness, in a water tunnel in the mountain.

Gypsum (two samples), from J. A. Whitaker, of Buena Park, Orange County. Sample No. 1 was analyzed by J. Koshland, of San Francisco; No. 2 by F. W. Roeding, of San Francisco, both students in the Agricultural Laboratory.

	No. 1.	No. 2.
Gypsum	68.19	38.85
Carbonate of lime	9.40	4.27
Iron and alumina	2.85	4.45
Sand, etc.	14.64	47.84
Moisture and loss	4.92	4.59
Totals	100.00	100.00

Of the above samples, No. 2 does not contain a sufficient amount of pure gypsum to warrant transportation, and is available only for local use.

Gypsum, sent by M. E. Mathes for the South Riverside Fertilizing Company. The sample was a grayish powder, having 55.35 per cent of pure gypsum and 33.14 of sand and other impurities. It is hardly of sufficient purity to warrant cost of long transportation, but can be used locally, in larger amounts per acre than if pure.

Gypsum, from Lawler & Smith, of Riverside. Samples sent are simply low-grade gypsums, which may do for neighborhood, but not for shipment to a distance, so long as there are commercial grades of 90 per cent and upward at command.

Gypsum, commercial sample, taken as an average of eight different sacks in the warehouse of the Paoli Gypsum Company at Mendota, and also samples from the deposit itself.

	Warehouse.	Deposit 1.	Deposit 2.
Gypsum	73.5	92.90	84.20
Sand and clay	19.5	7.10	15.80
Other impurities	7.0		
Totals	100.0	100.00	100.00

The impurities are in part doubtless due to the fact that the bulk of the gypsum was taken from the surface of the deposit, where sand and dust had been blown upon and imbedded in it. The samples taken

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from the deposit itself prove to be high-grade gypsum, and with care on the part of the laborers the commercial article can be greatly improved.

Gypsum (four samples), sent by F. W. Fowler, of South Riverside. No. 1 is an impure gypsum; No. 2, a white powder; No. 3, a gray earth in lumps, coated, and streaked with salt; No. 4, a coarse gray powder. An analysis of each gave the following result:

	No. 1.	No. 2.	No. 3.	No. 4.
Calcium sulphate (gypsum)	31.61	55.15	3.54	11.33
Calcium and magnesium carbonates	67.32	45.76	35.64	11.63
Calcium chlorid			1.60	
Calcium phosphate			1.96	2.53
Sodium chlorid			28.09	.96
Sodium carbonate			.99	1.19
Sodium sulphate				53.28
Silica	1.07	9.09	28.18	19.08
Totals	100.00	100.00	100.00	100.00
Phosphoric acid			.89	1.15

Nos. 1 and 2 are not sufficiently gypseous to render them of any value except as a local application to soils. Nos. 3 and 4 are of no practical value as fertilizers, the phosphoric acid being in an insoluble condition.

Gypsum sent by the Alpine Plaster Company, of Los Angeles. A cream-colored, soft, earthy powder, found in the gypsum beds. Sent for identification. It resembles somewhat the loose surface material that covers the beds of gypsum near Lovelocks, Nevada, and like it, is also rich in gypsum, as shown by the following analysis:

	Per Cent.
Insoluble matter	0.5
Gypsum	94.4
Carbonate of lime	5.1
Total	100.0

PAOLI GYPSUM COMPANY'S MINES, LOCATED NEAR MENDOTA, FRESNO COUNTY, CAL.*

By E. W. Hilgard.

The great importance of an abundant and reasonably cheap supply of gypsum as a fertilizer is recognized everywhere. Although not universally efficacious, like the phosphates, its favorable effect on the legumes—peas, beans, and clovers, including alfalfa—is enough alone to give it a prominent place in agriculture. Its special importance in California is due to the fact (first announced from the State Experiment Station) that it is an effectual antidote to the "black alkali" that afflicts some portions of the State; where it impregnates the soil, not so much in large, continuous tracts as in spots, varying from a fraction of an acre to several acres, where little or nothing can be grown, and which mar the continuity of fields, vineyards, and orchards.

Experience shows, moreover, that as a rule such spots extend their area as irrigation is practiced, invading bearing plantations of all kinds and causing loss and discouragement. Yet the fact that such lands

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when once reclaimed are profusely and lastingly productive, constitutes a strong incentive toward the utilization of the alkali lands, and renders the question of their reclamation for culture a very important one.

The characteristic ingredient of "black alkali" being carbonate of soda, it follows that when gypsum is applied to land impregnated with it, an exchange of chemical ingredients takes place, the sal soda being converted into Glauber's salt, or sulphate of soda, while the gypsum becomes carbonate of lime, or chalk. Glauber's salt, with more or less of common salt, constitutes the "white alkali," which is rarely abundant enough in the soils to form an obstacle to their cultivation, being many times less injurious to vegetation than the carbonate of soda.

But gypsum acts not only as a neutralizer of the injurious effect of the carbonate of soda on the plants themselves; it is also of essential benefit in that it renders friable, and therefore tillable, the hardpan always formed in "black alkali" lands; moreover, it serves to retain in the soil the humus and phosphates which the soda has dissolved, and which would be leached out of the land, to its great injury, if it were attempted to reclaim it by underdraining alone.

These good effects have been verified in practice many times over, outside of the successful experiments made at the Experiment Station near Tulare. But until now, gypsum (land-plaster) has been rather costly for general use, on account of the heavy cost for transportation from a distance to the points where it is mainly needed, viz.: in the upper San Joaquin Valley; nor has quality of the material furnished been always satisfactory.

It is thus a matter of no little interest that another mine has been found and partially developed, which combines a location near the chief consumers of land-plaster with an excellent quality of material easily mined and crushed for farmers' use. At the suggestion of John S. Dore, of Fresno, the writer has lately visited the new mine and believes the results of the examination to be of sufficient general interest for immediate publication.

This mine is located in the ridges bordering the west side of the Great Valley, just north of Tome Creek, and about five miles south of the Big Panoche. It was discovered in 1892 by J. H. Hall, of Selma, and is owned and worked by the Paoli Gypsum Company, of Selma and Mendota, Fresno County; the location being about 18 miles west-southwest from the latter station.

The main ridge, on which the gypsum appears at the highest level, extends about 3,000 feet along the creek, to which it falls off steeply. Toward the north there extend from this ridge four spurs, from one third of a mile to one mile long, on the crests of which the gypsum crops out abundantly, with a gentle dip toward the valley. The deposit on the crest of the main ridge, where most work has been done, shows a thickness of at least 30 feet, but its lower limit has not been exposed.

At the foot of the east slope of the third spur from the main summit, in a deep cañon and quite 150 feet vertically below the highest outcrop, there is a long exposure of a regular stratum about 18 feet thick so far as visible. Whether or not there exists a solid mass of the mineral from the outcrop to the summit, cannot be seen; should such be the case the mass would be enormous, but in any case the deposit is a very large one, sufficient to supply the needs of the San Joaquin Valley for a long time to come.

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The samples collected, which of course are essentially "croppings," show the material to be very nearly uniform from top to bottom; a yellowish-white, chalky mass, easily crumbled and therefore readily put in shape for farmers' use. Eight samples were selected to represent the outcrops on the crests of the several ridges and also the one in the cañon mentioned above. The analyses of four of these gave the following results:

	Gypsum.	Sand Moisture and Carbonates.	
		Clay.	Lime, etc.
No. 1, from summit of main ridge	95.24	1.98	2.78
No. 5, from second spur, middle of crest	91.74	1.52	3.74
No. 6, from third spur, in cañon	92.90	2.60	4.50
No. 7, from fourth spur, near road	82.20	8.21	3.75

These results render superfluous the analysis of the other four samples taken. It is probable that had sample No. 7 been taken farther from the surface most of the sand it contained would not have been found, since the rest contain none like it. It is probable that the average of the whole deposit ranges above 90 per cent, since the only one of the samples taken in the mass itself (No. 1, from the main workings thus far done) is the highest of all, and, counting out the 2 per cent or thereabouts of atmospheric moisture, is probably equal in purity to any gypsum thus far found in quantity west of the Sierra Nevada. Selected portions of the deposits will undoubtedly be available for burning into plaster of Paris for builders' use.

It is thus obvious that whenever this mine shall be worked on a proper technical basis, the other mines supplying plaster will have to look to their laurels in competition with it. It is proper to suggest in this connection that gypsum, like all other fertilizers, should be sold on the basis of a guaranteed percentage of the pure substance, and not simply by weight or measure. We have repeatedly heard of what has been bought for gypsum failing to produce any effect on black alkali, and have traced the cause to material bought for land-plaster, which contained little or no gypsum. In this matter, as in the fertilizer trade generally, the need of State control and inspection, such as exists in the majority of the States of the Union, becomes more and more apparent.

The Experiment Station is compelled to decline any responsibility as regards the materials actually furnished the farmers by dealers or manufacturers, even though samples of what purports to be the same material may have been analyzed here and such analysis may be attached to the packages. While we have reason to believe that the fertilizers supplied by reputable houses in California are what they are represented to be, to a degree unusual in States not exercising supervision, yet the impositions that are occasionally practiced tend to discredit not only those directly responsible, but to damage the fertilizer trade at large, and to discourage the free use of the *bona fide* articles by farmers. This is a case in which even the anti-paternalism of Secretary Morton must yield to what has been proved to be the only practical solution of the question of "fertilizers true to name."

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GYPSUM MINE IN SAN BENITO COUNTY.

Another important gypsum mine, of a character somewhat similar to the one just described, has been lately rediscovered in the Gabilan range, San Benito County, 10 miles east of Kings City, by Mr. E. S. Jones, of San José.

Specimens of the best portion of this deposit have been in the collection of the College of Agriculture for fifteen years past, but the finder disappeared without divulging the location. According to the best information obtainable the deposit lies with but a slight dip toward the Salinas Valley, in a series of ridges separated by ravines. Its upper portion consists of solid crystalline gypsum rock of gray tint and greatly resembling limestone, but much softer, yet still requiring an energetic crushing machine to reduce it. An analysis formerly made gave its purity at over 98 per cent. The thickness of this material is said to vary from 3 to 7 feet in various localities. This solid gypsum rock is underlaid by a large deposit of soft, marly material, containing from 40 to 60 per cent of gypsum, together with carbonate of lime, clay, and sand. This marl, while not suitable for transportation to a distance, could be very advantageously used for fertilization within easy hauling distances.

The ground gypsum rock has already been placed on the market at San José and elsewhere, and its use has been followed in many instances known to me by exceedingly favorable results, even outside of properly alkaline lands. It is to be hoped that before long it will be made more widely available to farmers.

CROPS AND FERTILIZERS, WITH REFERENCE TO CALIFORNIA SOILS AND PRACTICE.*

By E. W. Hilgard.

California has now become old enough to consider seriously the question of fertilization. It is true the lands of the State are exceedingly productive naturally; they are doubtless more so than most of those of the Eastern States, as our investigations have shown. And yet, the peculiar form which the agricultural interest has taken in California, that of horticulture, brings forward the question of fertilization in this State earlier than in other States of the same age. The reason is obvious. The investments made in orchards and vineyards are permanent; they are costly; they are to be maintained for a number of years. Unlike the annual crops which usually occupy the farmers in the States east and west of the Mississippi, or, more properly, between the Rockies and the Alleghanies, our plantings are expected to hold good for twenty, thirty, and even forty years; at least we hope so. And from this impracticability of change and rotation of crops comes the inconvenience of being obliged to make returns to the soil very much sooner than would otherwise be the case; for, as we all know, the continual cropping of land with one and the same crop is a very exhaustive process, and when the crops are annual and can be changed that is a very desirable course to pursue. One can, by continual cropping with the same crop,

* Read before the State Horticultural Society, May, 1892.

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reduce the production of his land to the lowest limit of profitableness in one third or one fourth the time it would have lasted if a change of crops had taken place. The cause we will discuss presently. Now, in the East the custom has been that when the land gives out the party moves farther west. But we cannot do that very well, and if we spread out sideways we will soon come in contact with regions where other people have already settled, and we would hardly want to leave California anyway.

Maintenance of Profitable Production.—To maintain profitable production we must *replace what the crops take away;* therefore, the first thing needful is to know what the crops *do* take away. It makes a material difference whether you take the whole plant and analyze it and its ashes, or only the *portion usually harvested;* a very wide difference. If root, branch, leaves, and fruit are taken away altogether, there will be found on the whole a remarkable similarity between crops of different sorts. If we take the apple tree with apples, orange tree with oranges, and the wheat plant as a whole—root, straw, ears, and all—we would not find a very great difference; but in cropping we take very different *portions* of the plants grown. In the case of wheat we take seed only; in the case of orchard trees we take the fruit besides the seed; of root crops we take only the root, etc. This brings about very wide differences in the material that we extract from the soil in cultivating different crops.

Take, for instance, wheat, which has occupied and still occupies a very large space in our agriculture. It has been the custom in early times to sell the grain and burn the straw. Now, if the straw had been burned standing all over the field after heading, that would not have been so bad; but when the straw was burned in stacks, the heat generated was so great as to reduce most of the ashes to glass, such as you see in the ash-pit of straw-burning engines. To burn the straw, therefore, took away from the soil just as large a portion as though it had been sold.

In the Southern States, not long ago, I saw that lands which, when originally cultivated, gave four hundred pounds of cotton lint to the acre, were being cultivated still, and now produce no more than one hundred pounds to the acre. But the actual expense of production, aside from picking and ginning, is now just as great as under former conditions, and under the production of four times as much per acre; and, of course, the people become bankrupt. It is the same with the wheat crop; the cultivation of large areas, with low production, becomes unprofitable.

When the returns that can be made from the offal and remnants of the crop are not sufficient, it becomes necessary to see how else they can be made most cheaply; because that is a condition of great importance. We can give back one and the same substance in different forms, and it may cost in one form three or four times more than in another. *How to manure most cheaply is the question.*

INGREDIENTS WITHDRAWN BY VARIOUS CROPS.

The table below gives the different ingredients withdrawn by the several crops mentioned, leaving out what is taken from the air by the plant. The portion of the table to the left of the column of "Total Ash" shows the ingredients of the ashes of each crop, in pounds per

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AMOUNT OF SOIL INGREDIENTS WITHDRAWN BY VARIOUS CROPS. (Pounds per Acre.)

	Potash	Soda	*Lime*	Magnesia	Brown Oxid of Manganese	Iron Oxid and Alumina	*Phosphoric Acid*	Sulphuric Acid	Silica	Chlorine	Total Ash	*Nitrogen*
GRAPES, 1,000 lbs.	5.00	0.10	1.00	0.40	.....	.....	1.52	0.50	0.30	0.10	.....	1.70
Crop of 10,000 lbs.	50.00	1.00	10.00	4.00	.....	.....	15.20	5.00	3.00	1.00	.....	17.00
Seeds, 646 lbs.	1.48	.....	.....	.....	.....	.....	5.75	.....	.....	.....	.....	.....
Flesh, 9,154 lbs.	47.44	.....	.....	.....	.....	.....	8.93	.....	.....	.....	.....	.....
Wood, 2,010 lbs.	15.69	0.67	21.60	3.30	.....	0.42	8.74	1.75	0.64	0.61	53.42	.....
PRUNES, 1,000 lbs.*	2.66	0.13	0.13	0.26	0.01	0.03	0.53	0.10	0.19	0.01	3.03	1.46
Crop of 30,000 lbs.	79.70	3.85	3.92	7.45	0.38	1.04	15.95	2.87	5.52	0.22	120.90	44.40
Pits, 1,635 lbs.	2.06	0.40	0.52	1.40	0.16	0.10	2.80	0.46	0.68	0.02	8.60	10.30
Flesh, 28,365 lbs.	77.64	3.45	3.40	6.05	0.22	0.94	13.15	2.41	4.84	0.20	112.30	34.10
APRICOTS, 1,000 lbs.*	2.83	0.55	0.18	0.20	0.01	0.09	0.71	0.16	0.41	0.02	5.16	2.29
Crop of 30,000 lbs.	84.98	16.36	5.45	5.96	0.33	2.65	21.38	4.57	12.15	0.94	154.80	68.70
Pits, 1,740 lbs.	1.36	0.42	0.83	1.43	0.19	1.51	5.36	0.65	0.31	0.19	12.25	15.00
Flesh, 28,260 lbs.	83.62	15.94	4.65	4.53	0.14	1.14	16.02	3.92	11.84	0.75	142.55	53.70
ORANGES, 1,000 lbs.*	2.11	0.11	0.99	0.23	0.02	0.04	0.53	0.23	0.03	0.04	4.32	1.83
Crop of 20,000 lbs.	42.28	2.16	19.72	4.61	0.32	0.83	10.60	4.52	0.56	0.80	86.40	36.60
Seeds, 240 lbs.	2.74	0.10	1.32	0.60	.....	0.06	1.61	0.36	0.08	0.04	6.90	.....
Flesh and rind, 19,760 lbs.	39.54	2.06	18.40	4.01	.....	0.77	8.99	4.16	0.48	0.76	79.50	.....
Roots, percentage	15.43	5.15	49.89	6.91	.....	1.02	13.47	5.78	1.75	0.72	100.12	.....
Stems, percentage	11.69	3.20	55.13	6.34	.....	0.57	17.09	4.64	1.22	0.15	100.00	.....
Leaves, percentage	16.51	5.21	56.38	5.72	.....	0.52	3.27	4.43	4.83	4.03	99.91	.....
OLIVES, 1,000 lbs.	8.55	0.76	2.32	0.54	.....	0.14	1.18	0.14	80.77	0.23	94.63	5.85
Crop of 2,200 lbs.	18.81	1.68	5.10	1.18	.....	0.30	2.59	0.30	177.72	0.50	208.18	12.86
Pits, 429 lbs.	6.77	0.57	4.01	0.91	.....	0.19	2.40	0.29	177.63	0.48	193.25	9.67
Flesh, 1,771 lbs.	12.04	1.11	1.09	0.03	.....	0.11	0.19	0.01	0.09	0.02	14.56	3.19
Leaves, 4,400 lbs.	58.05	2.10	88.53	8.48	.....	2.72	20.08	9.11	0.81	0.28	190.16	69.90
Wood, 11,000 lbs.	24.46	4.31	66.63	6.30	.....	4.02	14.87	2.00	0.59	.....	123.18	117.67
WHEAT, 1,000 lbs. (whole plant)	9.15	0.35	2.30	1.36	.....	0.39	4.13	1.44	30.52	1.65	51.26	8.75
Crop of 4,800 lbs. (hay)	43.92	1.68	11.04	6.52	.....	1.76	19.80	6.93	146.50	7.89	246.04	42.00
Grain, 20 bushels	7.85	0.14	0.72	2.57	.....	0.22	11.90	0.34	0.24	0.02	24.00	24.00
Straw, 3,600 lbs.	36.07	1.54	10.32	3.95	.....	1.54	7.90	6.59	146.26	7.87	222.04	18.00
ALFALFA, 1,000 lbs.	13.49	0.51	22.86	2.02	.....	0.53	6.43	4.16	13.41	1.59	65.00	13.96
Crop of 12,000 lbs.	161.88	6.12	274.32	24.24	.....	6.36	77.16	49.92	160.92	19.08	780.00	155.52

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SUGAR-BEETS (fresh), 1,000 lbs.	5.38	3.09	3.11	2.71	.....	0.23	1.61	1.12	0.62	0.86	18.73	2.38
Crop of 72,000 lbs.	387.44	222.48	224.08	195.60	.....	16.68	116.16	80.64	44.96	61.68	1349.72	173.40
Roots, 40,000 lbs.	152.00	24.00	16.00	24.00	.....	3.00	36.00	12.00	8.00	12.00	287.00	60.40
Tops, 32,000 lbs.	235.44	198.48	208.08	171.60	.....	13.68	80.16	68.64	36.96	49.68	1062.72	113.00
RAMIE, 1,000 lbs.*	8.84	1 76	23.08	5.90	0.12	1.80	6.46	1.70	24.71	1.12	75.19	12.97
Crop of 14.25 tons	251.98	50.14	657.82	168.27	3.57	51.43	155.70	48.56	704.25	51.85	2143.57	369.70
Leaves, 4.25 tons	68.13	8.99	566.91	114.58	1.92	38.56	77.13	30.86	692.71	41.56	1641.35	206.10
Stalk (without bark), 7.25 tons	155.99	33.63	71.77	43.68	1.45	12.16	67.71	14.53	7.06	2.50	410.48	105.85
Bark (cuticle and fiber), 2.75 tons	27.86	7.52	19.14	10.01	0.20	0.71	10.86	3.17	4.48	7.79	91.74	57.75
COTTON, 1,000 lbs.	11.00	4.44	13.76	4.28	.....	2.09	7.03	5.00	4.08	2.58	54.26	.....
Crop of 3,200 lbs.	35.26	14.21	44.04	13.71	.....	6.43	22.54	16.00	13.08	8.27	173.60	.....
Leaves, 400 lbs.	7.99	4.40	15.03	2.50	.....	2.38	4.22	5.84	3.58	2.75	48.69	.....
Stems, 1,200 lbs.	9.17	3.65	10.58	3.56	.....	0.75	4.49	1.99	1.71	2.54	38.44	.....
Seeds, 800 lbs.	8.99	1.15	3.07	4.00	.....	0.52	9.74	1.11	0.31	0.48	29.37	29.20
Burrs, 400 lbs.	7.42	4.59	14.16	3.19	.....	2.66	3.57	6.88	7.40	2.14	52.01	.....
Lint, 400 lbs.	1.69	0.42	1.20	0.46	.....	0.12	0.52	0.24	0.08	0.36	5.09	.....

*Analysis made at the Station laboratory.

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acre. Perhaps fault may be found with the estimates of crops upon which these figures are based; but if so, they can easily be brought up or down to any estimates desired by a little calculation on the thousand-weight, also given. On the right of the column of totals is placed nitrogen, a substance not contained in the ashes, but which by most plants is taken from the soil and not from the air, although it constitutes four fifths of it; and which it is highly important to return to the soil.

There are quite a number of ingredients that enter into the plant ash: potash, soda, lime, magnesia, phosphoric and sulphuric acids, etc. All, or nearly all, of these are proved to be necessary to the full development of the plant; but I have distinguished by darker type those which we find it *necessary* to return to the soil, and are therefore willing to pay for. The rest take care of themselves in nearly all soils. *Potash*, *lime*, *phosphoric acid*, and *nitrogen* are the four we generally take into consideration. But so far as we of California are concerned, we can do without one of these substances almost throughout the State, at least as far north as Mendocino on one hand, and perhaps Tehama and Shasta, and the higher foothills, on the other. This substance is *lime*, which, from a long series of analyses, I find is almost always abundant in the soils of all arid regions, from climatic causes. Umbrage must not be taken at the application of the word "arid" to California; it is the conventional word for regions of relatively deficient rainfall, where irrigation is required, or at least proves profitable.

I have recently obtained the results of a comparison of some four hundred and sixty soils from the Atlantic Slope (the Cotton States), with more than three hundred from the Pacific Coast (California, Oregon, and Washington), Montana, and a few from the interior (west of the Rocky Mountains). From these data it appears that the average lime percentage in the soils of the Eastern States, where summer rains prevail, is but a little over one tenth of one per cent (0.108 per cent). In California it is just ten times more (1.075 per cent). In the East it is found to be of great importance to supply this ingredient; liming and marling is a common agricultural operation. With us there is rarely any need of this, the lime being naturally present in the soil to a greater extent than can be accomplished by any practicable artificial application; it would be "carrying coals to Newcastle." I therefore leave the lime column out of consideration, in now calling attention to the differences in the draft made upon the soil by different crops.

In making up this table there has been considerable difficulty about getting the needful data, a portion of which are the results obtained in our own laboratory from California materials; these are marked in the table by a star (*). The rest have been drawn mostly from European, also from Eastern sources.

Grapes.—Grapes are placed at the top of the table, as one of the most important crops of the State. You can observe that the draft made by grapes as a whole (fresh grapes) is mainly on potash, and is quite heavy. If we do not return the pomace, the assumed crop of five tons takes away 50 pounds of potash, 15 of phosphoric acid, and 17 of nitrogen per acre.

Plums, Prunes, Cherries.—Take the next fruit, *plums* or *prunes*. There is quite a difference between the amount of potash which a crop of grapes and that which one of prunes or plums takes, but look at the amount of

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nitrogen which is withdrawn by the whole fruit; there is a heavy difference there. A fertile soil might be let alone awhile for the nitrogen which grapes withdraw, but it cannot be let alone long if heavy crops of plums are taken off, which take twice and a half times as much as grapes. *Cherries* draw upon the soil, weight for weight, about like prunes.

Apricots.—A crop of apricots draws somewhat more heavily on potash and phosphoric acid than do prunes; in nitrogen the difference is quite heavy, being nearly as two to one; while as compared with a crop of grapes, it is as four to one. So far as we now know, the apricot draws more heavily on the nitrogen than any other fruit crop.

Peaches, Apples, and Pears.—The peach runs somewhere between the plum and apricot; the apple crop is one of the least exhaustive fruit crops for its weight, say about two thirds or three fifths as much as the prune. The pear goes a little higher.

Oranges.—As regards the orange, it does not differ widely from grapes so far as potash and phosphoric acid are concerned; but in the matter of nitrogen the estimated crop of 20,000 pounds takes a little more than twice the amount withdrawn by 10,000 pounds of grapes; yet not as much as prunes, because so much more odd seed goes into prunes than oranges. It may be interesting to state in this connection that the nutritive value of the flesh of the orange is thus considerably higher than is that of the prune (two as against one and a half), but the apricot exceeds the orange in the ratio of two and one third to two.

Olives.—The case of the olive is quite peculiar, if we consider it simply as a source of oil. In the first place, the total *crop* is of much less weight than that of other fruits, yet the total weight of *ash* exceeds considerably that of any other fruit in the table. But when we analyze that ash we find that out of 208 pounds about 178 is silex—that is, flint—which is cheap, and of which all soils contain an abundance. Of the remaining 30 pounds nearly two thirds is potash. There is a trifle of phosphoric acid, and nearly 10 pounds of nitrogen. In these points it is unlike any of the other crops before us; but when we come to consider the product you really want to *sell*—the oil—we fail to find it in this table. The reason is that *as it takes nothing from the soil* it has no place there. *Its entire substance is taken from the air.* So the olive grower who returns all the pomace and other offal to the land from the outset, needs no other manure if his soil is naturally a fairly good one. It is largely for this reason that the olive has maintained itself so steadily in the oldest countries of the world; it does not wear out the soil. But of course, if we take the fruit, pickle it and sell it off, we must make returns to the soil, or our crops will soon fall short. What the olive then specially calls for is potash and nitrogen.

Wheat.—Let us now look at wheat as compared with the fruit crops. A crop of twenty bushels of grain takes out only about 8 pounds of potash; but it takes 12 of phosphoric acid, and 24 of nitrogen. Wheat, then, is not a consumer of potash, like the fruit crops; but it is quite heavy on nitrogen, particularly when we consider the small depth to which its roots penetrate the soil. What wheat draws from only eighteen to twenty-four inches of soil, trees and vines may take from a solid mass of six to ten feet depth. Taking this into consideration, even the 12 pounds of phosphoric acid count heavily; and accordingly it is a matter of experience that wheat culture necessitates specially the free use of phosphate and nitrogenous fertilizers.

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Hay.—Now as regards the hay crop: If a crop of wheat is cut for hay, the substances taken from the soil will be very nearly represented by adding together the figures of the table for the grain and straw. When the wheat is cut before maturity, about the same amount of plant (and animal) food is diffused throughout the plant more equally; if the grain is allowed to mature the phosphoric acid and nitrogen accumulate in the grain and the straw remains depleted, hence is a weaker cattle food. When the true grasses are used for hay the outcome is not widely different.

Alfalfa.—Next to wheat, the representative of the true grasses, is placed our great forage plant, alfalfa. It may be taken as representing the clovers at large, and measurably also peas, beans, and the like; the *legumes* we have agreed to call them. It is seen at a glance that it is a heavy feeder, even when compared with wheat-hay (the entire plant), weight for weight. But when we cultivate alfalfa on irrigated land we expect to make three cuts of two tons of hay each, say six tons in all, while of wheat expect only two or two and a half. Of course that makes the figures roll up, and 162 pounds of potash against 44 in wheat-hay, 77 of phosphoric acid against 20, 155 pounds of nitrogen against 42 in wheat, look formidable. In the matter of lime, alfalfa goes ahead of sugar-beets, though it remains far behind ramie. Like the clovers, it needs a limy soil for strong development; and that is one reason why with us alfalfa is so much more prized than "lucerne" is in the East. We have, naturally, just the lime-soils to suit it. But we need not fear that in fertilizing lands for alfalfa we will have to buy all that nitrogen at 17 cents a pound; for, in common with the rest of its kind—the clovers, peas, and beans—alfalfa provides that for itself, from the air. Here is a very important distinction, which alone makes it highly expedient that the vicious practice of calling all forage plants "grasses" should be done away with. The *true* grasses call for heavy supplies of nitrogen that must be furnished by the farmer; the "leguminous" forage plants "rustle for themselves" in that respect, and by using them for green-manuring we can supply the nitrogen required for grain crops much more cheaply than we can buy it from the fertilizer manufacturer. Again, their high content of nitrogen makes their hay specially valuable in putting flesh on our stock. It is not easy to overestimate the value of these nitrogen-gathering plants for general agriculture; and they should not be mixed up with the true grasses that perform entirely different functions in our rural economy.

Sugar-Beet.—Next comes the sugar-beet, in which so many are interested now, and which may be taken as representing the root crops in general. Here we have first, in contrast with wheat and its 246 pounds of ash for the total plant, not less than 1,350 pounds of ash taken from one acre, and if we include the 172 pounds of nitrogen, over three fourths of a ton of total soil ingredients, when the whole plant is removed. It is true that this total comes down to less than 350 pounds if we leave the leafy tops in the field; yet the roots alone remove twenty times as much potash as does wheat, three times as much phosphoric acid, and considerably over twice as much nitrogen. This is an enormous draft as compared with any of these other crops, especially on potash; but phosphoric acid and nitrogen are also drawn upon quite heavily. It will be observed that the draught of beets on all the substance is scarcely approached by any of the crops in the table, except alfalfa and ramie.

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But note, also, that the sugar, the commercially salable part of the beet crop, consists of nothing that is in this table at all; like the oil of the olive, *it comes entirely from the air*, and the rest can be given back to the land. The sugar-beet need not, therefore, be an exhaustive crop at all, provided all the offal be returned, which can be done without special difficulty.

Ramie.—Alongside of beets we have another crop which is exciting a great deal of attention—ramie. This also makes a heavy draft upon the soil. If we take the whole plant away, we have taken over one ton of ash in the 14 tons; containing 252 pounds of potash, not quite as much as the beet crop, but still a good deal. Observe the enormous draft upon lime; more than one fourth of a ton of lime is withdrawn per acre; therefore, ramie should not be planted on any soil that has not a great abundance of lime. That is an exceedingly important matter, because the soil would have to be limed within a few years after planting; but in most California soils there is as much lime as ever is wanted, particularly in the valleys. We have that natural advantage over any of the Eastern States that may attempt to plant ramie. The draft on phosphoric acid, also, is enormous. The nitrogen is far ahead of anything on the list; namely, 370 pounds. But this, remember, is largely because of the extraordinary *amount* of the ramie crop we expect to harvest. Over 14 tons of *any* kind of dry product would be very hard on the soil when we take it *all* away. But that is not at all necessary. The part of the ramie plant we are after is the *fiber;* all the rest can go back to the soil and help to produce more fiber. Let us see how much we really have to take away for that purpose. As a matter of fact, the *pure* fiber does not differ from pure sugar in its composition. All but a little ash comes from the air, and does not draw upon the soil at all. But practically we cannot take only the *pure* fiber; the least we can sell is the "crude fiber," the bark of the stalk. Now, this contains only about 92 out of the 2,143 pounds of total ash of the crop, or less than one twentieth of the whole; of nitrogen, only 58 pounds out of 370; of potash, 28 pounds out of 252; of phosphoric acid, 11 out of 156 that would be extracted by the whole plant. The real crop we sell, then, stands somewhere near the fruits—say oranges—in the necessary draft upon the soil.

But it is suggested that ramie growers may as well sell the leaves also, to paper manufacturers, to whom they are a welcome raw material. I greatly doubt that any price the manufacturer could afford to pay would enable you to buy back the heavy amounts of fertilizing material that would thus be carried off. The leaves, as you see, take nearly half of all the nitrogen, that most costly of all soil ingredients, for which you have to pay 17 cents per pound; also half of the total phosphoric acid, say at 6 cents per pound; and over one fourth of the potash of the whole crop, say at 4½ cents. From these figures you can readily calculate what you could afford to sell the leaves for, in justice to your pocket, aside from the loss in vegetable mold so brought about.

There is fortunately no sale for the *stalks;* they are broken into small bits by the decorticating machine, just in good shape to be returned to the field whence they came. But in practice, particularly when you make several cuts in a season, you should put them in piles to rot, with some plaster, to prevent loss of nitrogen. That, with the leaves left on the ground, will give you all the fertilizing material you will need for a number of years, on land that is at all adapted to ramie culture.

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In the case of the ramie, the difference between taking the *whole* plant, and the crop part only, is very great; and the farmer should from the outset make up his mind that he *must* make this return to the land, or he had better not start in on ramie culture at all.

Cotton.—But if ramie is a striking example, cotton is still more so. In cotton-growing the only substance usually aimed at is the fiber, the "lint," which constitutes about one eighth of the weight of the whole (dry) plant, and one third of the seed-cotton as picked. In this case the stalks, leaves, and burrs are always returned to the land, as they are of no use otherwise; they are left in the fields, and we have therefore to consider only the seed-cotton. Taking as a basis a 400-pound bale per acre of best upland, we see from the table of totals that all that mass of fiber contains only 5 pounds of ash, and no nitrogen at all; whereas the seed corresponding to it contains nearly 30 per cent of ash, and 29 pounds of nitrogen besides, making nearly 60 pounds of soil ingredients withdrawn by the seed, against the 5 in the lint, the balance of the 400 pounds being taken from the air, as in the case of olive oil and beet sugar. This is so small a proportion of the whole that in a soil of any fair native productiveness the return of the stalk and seed should keep it up for a century at least, if not forever. Here is an actual example: When I left the South in the seventies, a man in Georgia had continued to plant cotton on the same land for fifty years, returning faithfully every year the stalks and seed. That land was then producing more and better cotton than ever, although originally rather poor; about of such quality as would have been exhausted in seven or eight years if nothing had been returned. It is probably producing as well as ever to-day, if the same policy has been pursued by his successors.

But unfortunately he was the exception. The great majority of cotton planters before the war considered cotton-seed as a nuisance, to be gotten rid of in any possible way. It was allowed to rot idly about the gin-houses, making the negroes sick with its effluvia; it was burnt; it was actually hauled across the land on which it had grown, and dumped into the bayous. Then after awhile it began to be sold to the cotton-seed oil factories for a song; and the oil-cake was shipped to Old and New England as a cattle food and fertilizer. Observe that the oil, as in the case of the olive, is no loss to the land at all; but the *oil-cake* contains all the seed did, and is a highly valuable fertilizer.

The farmers of the Cotton States know better now; but no longer ago than 1880 I calculated that they were selling their seed at just about half the price for which they could buy back the ingredients in the form of commercial fertilizers. For ruinous absurdity this whole transaction is probably unique in the history of agriculture. Let us look for a moment at the practical results. In parts of Mississippi and Alabama, uplands that originally yielded a 400-pound bale per acre, and were hard to get at from $50 to $60, have gone a-begging for the taxes; they bore good crops for thirty years, and had the seed been returned would now be better than ever. The whole of the "Southern river counties" of Mississippi, from Vicksburg south, and the rich black prairies of eastern Mississippi, have had this fate. They are now being reclaimed largely by means of commercial fertilizers, at heavy expense, so far as they have not been ruined by the long abandonment and gullying. And just that will be the result everywhere, even in the rich valley of California, unless a different policy is pursued.

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HOW TO PREVENT EXHAUSTION OF THE SOIL.

It has been shown what each of the principal crops withdraws from the land; now let us consider what is the best and cheapest policy to pursue in preventing exhaustion—that is, a reduction of the crop below the paying limit. The first rule, as I have insisted in what I have said thus far, is to "return to the land faithfully all that is not very profitably salable." That is the rule to be first of all remembered and practiced. Some portions of crops may be returned directly, as in the case of ramie stalks; or the straw may be fed to cattle, and the manure put back; either way will do, only remember that the cattle carry off a part of the value of the feed with them.

Fertilizers.—The Eastern manufacturers offer as a special recommendation, "complete manures," that is, such as contain, in varying proportions, all of the three critical soil ingredients, potash, phosphoric acid, and nitrogen. That is well where all *are* wanted; but when, as is mostly the case with us, the soil's fertility is used up in a one-sided fashion, one-sided returns are as good as any, and a good deal cheaper. If only one or two of these ingredients are needed, why spend money for those not needed, thus "carrying coals to Newcastle"?

There is a principle involved here that I will formulate as briefly as I can: It is that if of all the ingredients of plant-food, a single one is lacking or is seriously deficient, the presence of all the rest is unavailing. Supply that missing one, and all the rest spring into activity, and your investment yields an enormous profit. *To find out just what the* deficient ingredient is in each case, is therefore a matter of very direct importance to the farmer's pocket.

In part, this question can in many cases be answered from the above table. If the crop grown draws chiefly upon potash, the presumption is that it will be best to supply a fertilizer containing largely that substance. But there is another consideration: Our soils vary as widely as do the crop ingredients withdrawn. Now, if the soil should contain an abundance of available potash, we may after all, in the supposed case, be "carrying coals to Newcastle."

I have already remarked that by far the majority of California soils are rich in lime, so as to render liming, so much practiced in the East, an unprofitable operation here. That knowledge was obtained by analyzing the soils of the State. The same series of analyses has shown that what is true of lime is nearly as true of potash—not quite so much so, for while in the case of lime the proportion between Eastern and California soils is as one to over ten, in the case of potash it is about as one to four in favor of our soils. It is plain, then, that to invest heavily in *potash* fertilizers, as is frequently advised, is likely to be in very many cases a useless expenditure.

Again, I have found that in some parts of the State, the San Joaquin Valley in particular, the soils in many localities contain an abundance of saltpeter, and therefore of available *nitrogen*, for which we would have to pay at the rate of 17 cents a pound. At other points the soil is full of soluble *phosphates;* so that if the crops do not succeed there, it is certainly not the phosphates that are needed to be purchased. Let me mention that such cases belong especially to the regions of the much-dreaded and maligned alkali soils, of which many people are so afraid that the word "alkali" must not even be mentioned in their hearing.

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When this matter gets to be properly understood, and people find that *an alkali soil means a rich soil*, requiring only to be rationally treated to become more highly productive than any others around it, the real estate agents will cease to try to hush up their very existence. But as this subject has already been treated of elaborately in the publications of the Experiment Station, I shall now say no more about it than to remind the reader that if he *does* cultivate some alkali soil, there is one substance that it will not need in a life-time; that substance is potash. Few of the alkali soils in this State contain less than 5 or 6 per cent of it. About Westminster, in Orange County, we found over 15 per cent; and at the San Joaquin Valley Experiment Station, near Tulare, we found that what with potash, phosphoric acid, saltpeter, and ammonia, the alkali in the worst part of our land would be worth $7 per ton at wholesale, as a complete, all-around fertilizer. All we will need to do there for years is to check the rise of the alkali by good cultivation, and to neutralize the "black" part of it with gypsum.

Irrigation Waters.—Again, there are the irrigation waters. Some are very pure, and some are not; some carry noxious "black" alkali, others only the "white," and some—particularly in the valley of Southern California—carry so much potash as to render any artificial supply uncalled for, so long as irrigation is kept up. Take the case of oranges at Riverside: an estimated crop of 20,000 pounds will take out of the soil about 42 pounds of potash. But the irrigation water used there will, at the ordinary rate, supply about 35 pounds of soluble potash per annum; and that, in soils which themselves already contain over 1 per cent of potash, by analysis, is pretty sure to keep up the supply without worrying over the importation of potash salts from Germany. It is otherwise in Florida, where not only they do not irrigate, but the soils contain something like a hundred times less potash than do those of California. But these same orange soils of ours are not very rich in phosphoric acid and nitrogen; therefore, I have advised growers to spend their valuable cash for these only, and not for "complete" fertilizers.

Analysis of Soils and Waters.—It will be seen, then, that in order to fertilize intelligently, and as cheaply as may be, we have to know not only what soil ingredients each crop takes away, but also which of them are scarce or abundant in the soils; and where we irrigate, in the irrigation waters. That is the work we are now trying to do at the Experiment Station. The composition of most of the crops we can, on a pinch, get from the work already done in the old country, although we find very considerable differences in composition, arising from the natural differences between old and virgin soils, and also from those of climate. But the soils and waters we must analyze for ourselves, and the job is not a light one; the more as we are short-handed, and have no funds for traveling to make a field survey—an agricultural survey of the State. It seems to me that the State appropriates money for very many less important things.

Meanwhile, the best we can do is to make personal observations when we have the opportunity, and for the rest we must rely on those interested to furnish us samples of soils and waters, along with such information as is always necessary in order to be able to judge intelligently of the value and adaptations of land. The last point is not always considered by those who send us a thimbleful or two of a soil that we see for the first time, and expect us from that to tell them, not only whether

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it is best for turnips or fruit, but also the exact varieties of either that will succeed best. Now, we do not claim to operate by witchcraft; we want to know the *facts*—all the circumstances and conditions of soil, subsoil, lay, climate, etc., that may influence crops or cultivation. These we combine with our examination of the soils, and from all that come to a common-sense conclusion. I have prepared a circular that will be sent to any one desiring to know more about his land, with directions how to take proper samples and to give what information is needed for our guidance. In very many cases we already know the soil from former examinations or experience, and can tell what is needed by merely identifying it; in other cases we must first analyze it; and that is a long job, which cannot be indefinitely repeated, short-handed as we are. You may have to wait some time before your turn comes when you have sent a sample; but we will get to it in the end.

The analysis of the *waters* of the State is giving us a great deal of work, and is scarcely less important than that of the soils, in an irrigation country. With the means we now have, all this together is slow work; but we will accomplish it in the end.

State Soil Map.—Of course, what we are aiming at is to make a complete soil map of the State, that shall present as much in detail as possible, the various soil regions and agricultural subdivisions of the State—the foothills, the great valley, the valley of Southern California, and the several subdivisions of the coast ranges. When we shall have classified the soils of these regions, first in general, then in detail, showing what are the virtues and deficiencies and peculiarities of each, we shall be able to answer quickly and fully the thousands of questions now asked from all parts of the State. For the present, we are preparing, with such data as we have, a general soil map of the State for the Columbian Exposition; and for the same we are getting up a set of representative soils from all parts of California.

Fertilizer-Control Law.—There is one thing I must not omit to commend to your earnest attention: It is the need of a "Fertilizer-Control Law," such as now exists in nearly all the Eastern States. The need of such a law arises from the fact that fertilizers are a kind of merchandise that the consumer is altogether unable to judge of, except from the good or evil results of its use; evil, I mean, in the sense of having spent one's money to no useful purpose. Only the chemist can control the intrinsic value of a fertilizer; but unless the law steps in, he can do no more than say what was the value of the sample sent him. What the stuff sold to the farmer may be, he cannot know unless the identity is assured by inspection of every lot put on the market, as is now the rule in the East. For this reason we now decline, at the Station, to make any analyses of fertilizers, save in case of suspected fraud; because the farmer is too apt to assume that so long as he sees a responsible name at the bottom of a column of figures, the stuff is all right.

I will add, in justice to the fertilizer manufacturers on this coast, that I have every reason to believe that most if not all of them give good value for the price asked. One trouble is that farmers are rarely willing to give a sufficiently high price for a first-class article; and thus the manufacturer is often compelled, in order to make sales, to dilute his high-grade material with something (called a filler) that will make up the weight of a ton to correspond with the low price paid. Now, considering the high freights and long distances in this State, one could

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much better afford to pay $60 instead of $30 a ton, for a high-grade article; the farmer can then, if he wishes, make two tons of it at home, by putting in any kind of dirt he pleases, and thus at least not have to pay freight on the dirt, as is now frequently done.

All this trouble and uncertainty ought to be done away with by the enactment, next winter, of an effective fertilizer-control law by the Legislature.

Stable Manure.—But before making a practice of buying fertilizers, be sure that first of all, all the offal of the crops, of whatever kind, be utilized on the land; and all the manure, preserved in a proper manner. Which means that the farmer must not allow his manure pile to be first leached of its best soluble portions by rain, and then permit it to "fire-fang" and burn itself out to little more than ash when the dry season comes. Perhaps he has found that when he plows-in long, strawy manure, such as comes from the stables, it frequently not only does no good, but helps to dry out the soil and make a bad stand. That is because we have no summer rains to make it rot in the soil; and yet a portion of the manure is always lost, even by curing it carefully in the pile—some of the nitrogen or ammonia is sure to go off or be rendered unavailable. To prevent this as much as possible, keep the manure pile moderately moist all the time, and always keep some gypsum (land plaster) ready to strew on top of every new addition made to it. That fixes the ammonia, and pays better than to let it waste and then buy from the manufacturer.

Of late there has been some *burning* of manure, with the idea of getting a good fertilizer in the ash. I lately had a sample of such ash from Southern California, sent to me for information as to what a farmer might afford to pay for it. My answer had to be, "Just nothing at all"; because in burning the temperature had risen so high as to make little glass beads of nearly all of the ash; and it would have been of just as much use as these for fertilization, just as in the case of the clinker from straw-burning engines, before mentioned.

It hardly needs to be said that in order to use the manure, as well as the land itself, to the best advantage, a change of crops is desirable whenever feasible. One can thus avoid the one-sided wear, which is good for neither land, tools, beast, nor man, because sure to make any and all of them give out sooner. But as orchardists cannot avoid such one-sided wear, let them put in the cash in one-sided returns, where they will do the most good.

Application of Fertilizers.—As to the time and mode of applying fertilizers, there must be some difference made according to their nature. For instance, if nitrogen in the form of saltpeter is put on in the autumn, the winter rains will wash it through the soil. The same in the form of ammonia salts or tankage would not waste seriously, and would help winter crops. Potash and phosphoric acid may be used at any time, as all but the most leachy soils will retain them anyway. With us especially, the most soluble superphosphates will be made insoluble, though by no means ineffective, so soon as they touch our limy soils. For this reason it will not do here, as it does in the East, to put such fertilizers merely on the surface of the ground, for the rains (or irrigation) to wash in. They are apt to stay right *at* the surface, and if the roots of the trees have to go there for them, when the dry, hot season comes both roots and phosphates will be of little use to the tree. In sandy, pervious soils par-

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ticularly, fertilizers must be put far enough down to place them beyond the reach of the summer's heat and drought; cultivate or plow them in, as the case may be. Only the saltpeter is best put on the surface and irrigated in; it is very soluble in water, and remains so, and if it comes too near the roots of orange trees in strong solution it is very apt to do harm.

Drainage.—But however important fertilization may be, it is not all that is needed for the welfare of fruit trees. Most of them require, above all, a deep and well drained, and preferably, a light soil; for instance, it is not worth while to plant cherries or citrus trees in heavy adobe, as some of us have found out to our sorrow. To illustrate: At my home place in Berkeley, where I have a pretty stiff adobe, I planted some cherry trees for family use. They did very well for a few years, evidently until their roots got down into the close subsoil; then they began to droop and quit bearing. Not liking to lose them I laid an underdrain about four feet deep; in a short time the trees revived and are now doing very well. Mr. Wheeler, near Rutherford, Napa County, had an exactly similar experience with cherries and grapes.

Few culture plants and no fruit trees do well with "wet feet." This is just what is the matter in some of our irrigation districts, where leaky ditches have caused the bottom water to rise within a few feet of the surface, not only causing diseased roots, but taking away, by swamping, half or more of the soil that should have nourished the trees and vines. There it will not do any good to fertilize; it is not the lack of plant-food, but the impossibility of getting at it that makes the trouble, and one cannot make a deep-rooted plant do well in a shallow soil. That means underdrainage.

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VI. FRUIT AND VEGETABLE PRODUCTS.

INVESTIGATION OF FOOD MATERIALS.

By M. E. Jaffa.

Owing to the great pressure of work in other directions, not as much time has been devoted to this part of the chemical investigations as its importance calls for or as its intrinsic value justifies.

The analyses of sweet potatoes reported on page 219, and the data herewith appended, constitute the work done in this direction. We hope in the next report to present considerably more.

ANALYSES OF ALFALFA HAY, WHEAT, AND ITS BY-PRODUCTS.

For a discussion of the principles involved and of the terms used, see Bulletin No. 100 of this Station, on page 119 of Report for 1891–92.

In Table I will be found the analyses of alfalfa hay and wheat from the San Joaquin Valley, wheat bran, and wheat screenings. The samples of alfalfa hay and of wheat screenings were sent by Mr. W. P. A. Brewer, of San Mateo, and those of the wheat and bran by Mr. J. W. H. Campbell, of San Francisco.

Alfalfa.—In Bulletin No. 100 is given an analysis of alfalfa, which was very unsatisfactory, inasmuch as the sample from which the analysis was made consisted almost entirely of stems. The results here presented have been obtained from a representative sample, and an examination of them will show that they agree quite well with the per cents given for the average of twenty-one analyses of the same fodder grown elsewhere. If the California sample were reduced to the same percentage of moisture, 8.44, given for the Eastern average, it would show somewhat higher figures for the important food ingredients than does that average, as is indicated by the following tabular statement:

	California.	Eastern, Average.
Protein	14.63	14.28
Fat	2.68	2.15
Nitrogen-free extract	46.04	42.68

Wheat.—From an inspection of the data given for California wheat, it will be seen that there is but little variation from the average obtained from three hundred and ten analyses of the same food material grown east of the Rocky Mountains.

Bran.—It will be noted that the bran made in California contains considerably less crude protein, or nitrogenous matter, than does the same by-product from the East, as shown in the averages, by the figures 13.44 and 15.40, respectively. The fat percentage is also slightly lower for the California food. The sample of bran represented by the first

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TABLE I. COMPOSITION OF THE FODDERS.

	Number of Analyses.	Original Substance.										Potential Energy in One Pound	Nutritive Ratio
		Percentage Composition.						Amount Digestible in 100 Pounds.					
		Moisture.	Pure Ash.	Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.	Crude Fat.	Crude Protein.	Crude Fat.	Crude Fiber.	Nitrogen-Free Extract.		
Hay.													
Alfalfa (California)	1	11.92	5.89	14.10	21.25	44.27	2.57	10.58	1.23	9.77	30.10	990	1:4.1
Alfalfa (Eastern), average	21	8.44	7.44	14.28	25.01	42.68	2.15	10.71	1.03	11.50	29.02	977	1:4.0
Grain.													
Wheat (California)	1	12.07	1.69	11.11	2.75	70.54	1.84	8.90	.77	2.49	61.37	1,376	1:7.4
Wheat (California), average	5	11.35	1.74	11.31	2.60	71.09	2.08	9.05	.87	2.34	61.85	1,399	1:7.3
Wheat (Eastern), average	310	10.50	1.80	11.90	1.80	71.90	2.10	9.57	.88	1.67	63.05	1,419	1:6.9
By-Products, Etc.													
Wheat Bran (California)	1	13.65	3.05	11.90	6.81	61.82	2.77	9.28	1.91	1.70	47.60	1,170	1:5.8
Wheat Bran (California), average	4	12.42	5.61	13.44	8.52	56.41	3.74	10.48	2.58	2.13	43.43	1,151	1:5.2
Wheat Bran (Eastern), average	88	11.90	5.80	15.40	9.00	53.90	4.00	12.03	2.78	2.25	41.47	1,152	1:4.2
Wheat Screenings (California)	1	11.42	2.50	11.20	5.53	66.72	2.63	5.97	1.42	3.04	48.00	1,120	1:9.1
Wheat Screenings (California)	1	10.90	3.39	8.93	5.43	68.55	2.80	4.76	1.52	2.99	49.35	1,126	1:11.8
Wheat Screenings (California), average	2	11.16	2.94	10.06	5.48	67.63	2.72	5.36	1.47	3.02	48.67	1,123	1:10.4
Wheat Screenings (Eastern), average	10	11.62	2.91	12.48	4.93	65.11	2.95	6.66	1.60	2.71	46.88	1,114	1:8.0

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analysis was not thoroughly or completely sifted from the flour, which accounts for the very high percentage of nitrogen-free extract, 61.82, as against 56.41 and 53.90, the averages for California and the East, and also for the low contents in ash, crude fiber, and fat.

Wheat Screenings.—The wheat screenings of this State, like the bran, contain less of albuminoids (as indicated by the crude protein percentages) than is found in the same material produced in the Eastern States. This is proved by the figures 10.06 for the average of two analyses of the home product compared with 12.48 per cent stated for the average of ten analyses of the Eastern fodder.

As regards the other constituents of this feeding stuff compared with the Eastern averages, there are not any marked differences to be noted.

COMPOSITION OF FINE AND COARSE FLOUR.

It has been stated that the differences in the results of the analyses of California and Eastern wheats are only very slight; but a comparison of the corresponding analyses of fine and coarse flour, on the other hand, shows a decided discrepancy with reference to the albuminoid or nitrogenous matter.

Upon the completion of the first analysis of California fine flour it was noted that the percentage of albuminoids fell far short of the figure given for the Eastern average obtained from twenty-two analyses. Thinking that perhaps the sample referred to was not a representative one for California fine flour, two others were secured from different sources and analyzed. The results corroborated fully those of the previous analysis, thus proving that the California flour is much poorer in nitrogenous compounds than the Eastern flour of the same quality.

The same statement applies to graham flour.

The table below shows in detail the composition of fine and coarse flour.

Nutrients: Protein.—The marked difference in respect to the albuminoids is seen when comparing the per cents, 7.90 for California, with 11.00 to the credit of the Eastern flour.

Fats and Carbohydrates.—The contents of these two elements of foods are slightly higher for the products of this State than they are for the same material from the East.

Mineral Matter: Ash.—The flours, both fine and coarse, of California and of the Eastern States, contain, respectively, nearly the same quantity of mineral matter, as indicated by the ash percentages. It will be noted under the head of phosphoric acid, that while the percentage of this acid in the ash of the different flours is about the same, amounting to almost one half the ash, when we refer it to the flour as 100, the coarse material shows 0.75 as against 0.23 for the fine flour. This is owing to the total ash in the former case being about three times that obtained for the latter. It must not be supposed that because the coarse or graham flour contains higher percentages of nitrogenous and mineral matter then does the fine flour, it is therefore in proportion more nutritious. The increased amounts of these elements come from the bran, *very little* of which is digested by the human stomach.

Potential Energy.—It will be seen that the figures for potential energy do not differ materially for the several flours. This is due to the fact that in calculating the energy, albuminoids and carbohydrates have the same value.

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TABLE II. COMPOSITION OF WHEAT FLOUR.

	Number of Analyses	Water	Nutrients.					Potential Energy in One Pound	Phosphoric Acid Per Cent in Ash	Phosphoric Acid in Original Substance
			Total.	Protein.	Fat.	Carbohydrates.	Mineral Matters.			
Fine flour (California)	1	15.63	84.37	8.75	1.23	73.90	.49	1,588	49.72	.24
Fine flour (California)	1	13.45	86.55	7.17	1.35	77.44	.50	1,629	45.17	.23
Fine flour (California)	1	12.35	87.65	7.79	1.58	77.86	.42	1,659	53.08	.23
Fine flour (California), average	3	13.81	86.19	7.90	1.39	76.40	.47	1,627	49.32	.23
Fine flour (Eastern), average	22	12.50	87.50	11.00	1.10	74.90	.50	1,645	.....	.....
Coarse flour (California)	1	12.12	87.88	8.50	1.96	75.84	1.58	1,650	47.23	.75
Coarse flour (Eastern), average	3	13.10	86.90	11.70	1.70	71.70	1.80	1,625	.....	.....

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SUGAR-BEETS.

By M. E. JAFFA.

Sugar-beets, from D. B. Wier, of Trenton, Sonoma County.

"The beets were planted about the first of June on new, rough, but well-prepared mountain land, and received no cultivation whatever. I am sure the seed was not of the best, some of the plants showing red leaf stems. It is a very great mistake to plant beets on rich valley soils carrying great quantities of humus and nitrates. It was tested by thorough experiments on the best prairie soils of Illinois twenty-five years ago, and resulted in a miserable failure. The experiment shows that western Sonoma has many thousands of acres of the very best sugar-beet soils, and best climate in which to work them, where they can be grown to perfection each year with no expensive irrigation."

The samples were received in good condition on September 29th, and analyzed the following day. The average weight of the beets was 330 grams.*

Specific gravity of juice	1.0655
Solid contents of juice	16.00
Sugar percentage of juice	14.125
Purity coefficient	88.30
Saline coefficient	16.81
Ash percentage of juice	.84

These are excellent beets, with proper weight, high sugar percentage, medium ash, and high purity coefficient.

Sugar-cane, grown on the alluvial soil of Andrus Island, Sacramento River; sent by L. F. Smith, of San Francisco. The sample was received on September 14th, and analyzed on the following day.

Specific gravity of juice	1.0800
Solid contents of juice	19.04
Sugar percentage of juice	2.44
Purity coefficient	12.80
Saline coefficient	2.46
Ash percentage of juice	.98

This cane is too poor in sugar and too low in purity coefficient to be worked for sugar.

Sugar-beets, grown on alluvial soil of Andrus Island, Sacramento River; sent by L. F. Smith, of San Francisco. The samples were received on September 14th, and analyzed on the following day. The average weight was 1,300 grams, or 2.9 pounds.

Specific gravity of juice	1.0372
Solid contents of juice	9.30
Sugar percentage of juice	5.06
Purity coefficient	54.40
Saline coefficient	4.86
Ash percentage of juice	1.04

These beets are above the limit in weight allowed at the factories. The solid content of the juice is very low, while the percentage of sugar is deplorably low—less than one half of what it should be. The latter with a very high ash percentage brings the purity coefficient very far below the standard of 80 per cent.

*30 grams equal one ounce.

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Sugar-beets, from J. B. Compton, of Williams, Colusa County. The samples were received on October 19, 1893, and analyzed the following day. They had an average weight of 588 grams, or 1.2 pounds.

Specific gravity of juice	1.0678
Solid contents of juice	16.50
Sugar percentage of juice	10.78
Purity coefficient	65.31
Ash percentage of juice	1.38

While of about the right size and weight these beets are below the standard required by our sugar-makers, both as regards purity and sugar contents. Either the seed was not true to name, or, perhaps, excessive irrigation caused the deficiency, for there seems to be no good reason why good sugar-beets should not be grown at Williams.

Sugar-beets, from Williams, Colusa County; sent by J. B. Compton. The samples were received in good condition on October 11, 1892, and analyzed the following day. There were six beets, the average weight of which was 1,107 grams, or more than two pounds.

Specific gravity of juice	1.0352
Solid contents of juice	8.81
Sugar percentage of juice	4.72
Purity coefficient	53.57
Saline coefficient	4.72
Ash percentage of juice	1.00

These beets are above the weight permissible in good sugar-beets. Then, too, the amount of sugar is so low as to make them worthless for the production of sugar. It is probable that the seed was not true to name.

CALIFORNIA SWEET POTATOES.

By M. E. Jaffa and Marvin Curtis.

The sweet potato is such a staple article of food and so important a vegetable that it was desired to test its adaptability to the soil and climate of Southern California. Twenty varieties were planted at the Experiment Station near Pomona. Seventeen of these were analyzed and form the subject of this paper.

As this is our first publication regarding California sweet potatoes, and not having, for this year, any complete data for the samples, concerning the character of the flesh when cooked, the time of ripening of each, or the yield per acre, it may not be out of place to quote, for the varieties examined, from Bulletin No. 28 of the Texas Agricultural Experiment Station, the following table:

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TABLE I. YIELD PER ACRE, ETC., OF SWEET POTATOES.

Name of Variety.	Season.	Character of Flesh when Cooked.	Yield per Acre, in Bushels.		
			Merchantable.	Culls.	Total.
1. Bermuda	Late	Light yellow, dry	101.00	24.18	125.18
2. Big-Stem Jersey	Medium	Pale white, dry, and hard	51.90	43.37	95.27
3. Tecotea					
4. Golden Stem					
5. Shanghai (California)	Late	White, rather dry	164.23	35.53	199.76
6. Barbadoes	Late	Bluish white, soft, and strong	17.26	10.89	28.15
7. Early Golden	Late	Yellow, soft, and dry	79.90	18.16	98.06
8. Matejito					
9. Vineless	Early	Light yellow, soft, and mealy	156.45	30.87	187.32
10. New Jersey	Early	Light yellow, soft, and mealy	42.37	7.56	49.93
11. Hayman	Late	Pale yellow, dry, and mealy	31.50	9.00	40.50
12. Dog River	Late	Yellow, soft, and wet	11.24	8.65	19.89
13. Yellow Nansemond	Medium	Yellow, soft, and damp.	41.26	30.60	71.86
14. Red Nansemond	Late	Pale yellow, sweet	43.71	8.17	51.88
15. Norton	Late	Dull white, soft, and strong	46.94	7.51	54.45
16. Peabody	Late	Creamy yellow, dry, and hard	82.50	22.96	105.46
17. Pumpkin Yam	Late	Red, soft, and sweet	46.09	29.33	75.42
Average			65.45	20.48	85.93

It is thus seen that the largest yield per acre is 200 bushels, obtained from the Shanghai (California), a late variety. The product of the Vineless is 187 bushels, with early season.

Bermuda and Peabody, both late, show 125 and 105 bushels, respectively.

The lowest amount per acre is 20 bushels, derived from the Dog River variety, which is also late in ripening.

The average is 86 bushels, which is somewhat low, as that for the whole State of Texas is slightly over 100 bushels per acre.

A detailed description of each sample analyzed will be found in the report of Mr. Chas. H. Shinn, Inspector of Stations, on the Southern California Station.

The results of the chemical analyses are given below in Table II, *A* representing the percentage composition of the fresh material, and *B* that of the water-free substance.

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TABLE II. ANALYSES OF SWEET POTATOES GROWN AT THE SOUTHERN CALIFORNIA STATION.

Number	Variety.	A. Per Cent on Fresh Substance.								B. Per Cent Calculated to Water-Free Substance.						Number
		Water	Pure Ash	Crude Protein	Crude Fat	Nitrogen-Free Extract.		Total Nitrogen-Free Extract.	Crude Fiber	Pure Ash	Crude Protein	Crude Fat	Nitrogen-Free Extract.		Crude Fiber	
						Sugar by Copper Test.							Sugar by Copper Test.	Total Nitrogen-Free Extract.		
						Before Inversion.	Total, After Inversion.						Before Inversion.	Total, After Inversion.		
1	Bermuda	66.29	1.19	3.42	.56	*	*	25.72	2.82	3.54	10.14	1.66	*	*	76.29	8.36	1
2	Big-Stem Jersey	65.78	1.16	2.53	.74	*	*	26.15	3.64	3.39	7.36	2.16	*	*	76.46	10.63	2
3	Tecotea	62.94	1.35	3.23	.96	*	*	27.89	3.63	3.64	8.71	2.59	*	*	75.27	9.79	3
4	Golden Stem	70.89	1.10	1.58	.64	.79	3.81	22.77	3.02	3.80	5.42	2.20	2.73	13.09	78.20	10.38	4
5	California	75.28	1.01	1.29	.59	1.17	5.17	19.48	2.35	4.09	5.25	2.37	4.74	20.92	78.78	9.51	5
6	Barbadoes	45.81	1.98	2.32	.83	5.64	20.86	43.52	4.54	3.66	4.28	1.54	10.42	38.50	82.13	8.39	6
7	Early Golden	67.03	1.24	2.25	.77	3.23	10.28	26.24	2.47	3.78	6.82	1.72	9.80	31.20	80.16	7.52	7.
8	Matejito	67.54	1.24	1.59	.68	*	2.18	25.71	3.24	3.83	4.90	2.10	*	6.73	79.17	10.00	8
9	Vineless	67.91	1.11	2.44	.63	3.14	8.81	25.97	1.94	3.45	7.61	1.95	9.80	27.47	80.93	6.06	9
10	New Jersey	75.96	.70	1.09	1.76	3.16	8.01	18.41	2.08	2.90	4.55	7.34	13.16	33.33	76.57	8.64	10
11	Hayman	68.55	1.14	1.92	.40	*	2.39	25.01	2.98	2.00	6.12	1.28	*	7.60	81.11	9.49	11
12	Dog River	66.36	1.15	2.03	1.35	4.00	7.28	26.25	2.86	3.44	6.03	4.03	11.90	21.64	77.99	8.51	12
13	Yellow Nansemond	72.32	1.08	2.06	1.26	.78	1.96	20.64	2.64	3.91	7.43	4.56	2.82	7.10	74.56	9.54	13
14	Pumpkin Yam	66.91	1.24	1.82	2.50	3.36	8.08	25.72	1.81	3.77	4.25	7.57	10.20	24.50	78.91	5.50	14
15	Norton	67.67	1.21	1.65	.81	2.23	5.92	26.71	1.95	3.75	5.10	2.50	6.90	18.31	82.60	6.05	15
16	Peabody	68.48	1.26	1.87	.57	2.07	3.77	25.53	2.29	4.01	5 97	1.82	6.58	11.98	80.29	7.91	16
17	Red Nansemond	72.73	1.17	1.57	1.77	1.01	1.15	21.18	1.58	4.29	5.77	6.50	3.70	4.22	77.62	5.82	17
	Averages	69.00	1.15	2.08	1.00	2.33	5.55	24.23	2.62	3.60	6.23	3.17	7.73	19.00	78.70	8.35	
	Averages of 21 varieties from analyses made at Texas Agr. Expt. Sta..	70.27	1.14	2.41	.99	3.42	6.81	24.00	1.26	3.83	8.10	3.33	11.50	22.90	80.73	4.25	

* Not determined.

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The above analyses show the water to vary from about 76 per cent in the Shanghai (California) to 63 in the Tecotea.

The amount occurring in the Barbadoes is exceedingly small, and due to the fact that the sample was somewhat dry before the analysis was undertaken; for that reason it is not included in the averages calculated from the analyses of the fresh substance.

In order that an intelligent, and at the same time, practical comparison may be made of the different varieties, the results given in Table II have been calculated to a basis of 70 per cent water, that being about the average amount contained in the commercial article. Table III shows the results so calculated.

TABLE III. ANALYSES OF SWEET POTATOES.

(Results calculated to 70 per cent water.)

	Pure Ash	Crude Protein.	Crude Fat.	Nitrogen-Free Extract.			Crude Fiber.
				Sugar by Copper Test.		Total Nitrogen-Free Extract.	
				Before Inversion.	Total, After Inversion.		
1. Bermuda	1.06	3.04	.50	*	*	22.89	2.51
2. Big-Stem Jersey	1.02	2.21	.65	*	*	22.92	3.19
3. Tecotea	1.09	2.61	.78	*	*	22.58	2.94
4. Golden Stem	1.14	1.63	.66	.82	3.93	23.46	3.11
5. Shanghai (California)	1.23	1.58	.71	1.43	6.28	23.63	2.65
6. Barbadoes	1.10	1.28	.46	3.13	11.55	24.64	2.52
7. Early Golden	1.13	2.94	.52	2.94	9.36	24.05	2.25
8. Matéjito	1.15	1.47	.63	*	2.02	23.75	3.09
9. Vineless	1.04	2.38	.59	2.94	8.34	24.27	1.82
10. New Jersey	.87	1.37	2.20	3.95	10.00	22.97	2.59
11. Hayman	.60	1.84	.38	*	2.28	24.33	2.85
12. Dog River	1.03	1.81	1.21	3.57	6.49	23.40	2.55
13. Yellow Nansemond	1.17	2.23	1.37	.85	2.13	22.37	2.86
14. Pumpkin Yam	1.13	1.28	2.27	3.06	7.35	23.67	1.65
15. Norton	1.12	1.53	.75	2.07	5.49	24.78	1.82
16. Peabody	1.20	1.79	.55	2.07	3.59	24.09	2.37
17. Red Nansemond	1.28	1.73	1.95	1.11	1.27	23.29	1.74
Average	1.08	1.86	.95	2.36	5.71	23.60	2.51
Average of 21 varieties from Bulletin 28, Texas Agricultural Experiment Station	1.14	2.41	.99	3.42	6.81	24.00	1.36

* Not determined.

Ash.—From the above data it will be noted that while the mineral contents, as indicated by the ash percentage, is quite low, the average being only 1.08, there are marked differences between some of the varieties in this respect. The lowest, 0.60, is found in the Hayman. Red Nansemond contains the highest percentage, 1.28, of this ingredient Shanghai (California), with 1.23, and Peabody, with 1.20, approach quite closely to this latter figure.

Albuminoids or Nitrogenous Matters (Crude Protein).—Of this important food constituent the Bermuda has the most, 3.08 per cent, which is considerably more than the average, 1.86, for the seventeen varieties examined. The Vineless, much in favor in Texas, shows 2.28 per cent. The lowest contents, 1.28, is given both for the Barbadoes and the Pumpkin Yam.

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Fat.—This forms only a small part of the composition of the sweet potato. Less than 1 per cent is the average. But five of the samples contain quantities above that figure, viz.: New Jersey, 2.20; Pumpkin Yam, 2.27; Red Nansemond, 1.95; Yellow Nansemond, 1.37, and the Dog River, 1.21 per cent.

Nitrogen-Free Extract.—Starch, sugar, gums, etc., are included under the above head, the former predominating. The total *sugar* reaches a maximum of 11.55 in the Barbadoes and a minimum of 1.27 in the Red Nansemond. Among the high percentages may be noted the New Jersey, with 10.00; the Early Golden, 9.36, and the Vineless, with 8.34.

The Matejito, Hayman, and Yellow Nansemond show extremely low sugar percentages, as indicated by the figures 2.02, 2.28, and 2.13, respectively. The average for the fourteen varieties in which the sugar was determined is 5.71.

The *total* nitrogen-free extract varies but little, in the different samples, from the average, 23.60; the highest figure, 24.78, being stated for the Norton, and the lowest, 22.37, for the Yellow Nansemond.

When comparing the averages for the seventeen samples analyzed with that obtained from twenty-one analyses of different varieties from Texas (Bulletin No. 28, previously referred to) it is seen that the Texas potatoes contain about 33⅓ per cent more *protein*, as shown by the figures 1.86 and 2.41; about the same amount of *fat;* and are richer in total sugar to the extent of one fifth, as indicated by the percentages 5.71 and 6.81, respectively.

The averages, 1.08 and 1.14 for the mineral matter, are about the same, while percentage of crude fiber for the California potato, 2.51, is just double that, 1.26, given for the Texas average.

Further analyses will perhaps tend to lessen these differences, as the samples analyzed from the Southern California Station were the first ones grown there and may have been harvested before maturity.

COMPARISON OF THE COMPOSITION OF THE IRISH AND SWEET POTATO.

The question of the relative nutritive values of the Irish and sweet potatoes often being asked, we append the following little table giving the composition of both.

Not having any analyses of the Irish potato grown in California, we make use of the average of twelve analyses, given in the fourth annual report of the Storrs School Agricultural Experiment Station, Storrs, Conn., for 1891.

TABLE IV. COMPOSITION OF IRISH AND SWEET POTATOES.

	Number of Analyses	Water, Per Cent.	Nutrients, Per Cents.					Potential Energy in One Pound
			Total	Protein	Fat	Carbohydrates	Mineral Matter	
Irish potatoes	12	78.9	21.10	2.10	.10	17.90	1.00	375
Sweet potatoes (California)	17	70.0	30.00	1.86	.95	23.60	1.08	537

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We thus perceive that for a given weight there is considerably more nourishment in the sweet potato than there is in the white or Irish. The potential energy in the latter case is only about two thirds of that contained in the former.

COMPOSITION OF THE ASH OF THE SWEET AND IRISH POTATOES.

To ascertain the amount of mineral matter withdrawn from the soil by a crop of sweet potatoes an analysis was made of the ash. The results are given below. The analysis was made by P. W. Tompkins, a student in the Agricultural Laboratory. The analysis of the ash of the Irish potato, taken from Johnson's "How Crops Grow," is placed alongside for comparison.

	Sweet Potato, Per Cent.	Irish Potato, Per Cent.
Potash	58.16	60.90
Soda	8.12	1.90
Lime	5.64	2.40
Magnesia	4.10	4.60
Peroxid of iron, and alumina	.54	.30
Brown oxid of manganese	Trace.	Trace.
Phosphoric acid	16.17	18.30
Sulphuric acid	2.99	7.00
Silica	2.56	1.90
Chlorine	2.14	2.70
Totals	100.42	100.00
Less excess of oxygen due to chlorine	.42	.00
Totals	100.00	100.00

Of the three most important ingredients: potash, lime, and phosphoric acid, potash predominates and constitutes more than one half the mineral contents of this food. Phosphoric acid amounts to about 16 per cent of the ash of the sweet potato and 18 per cent of the Irish; while the quantity of lime contained is quite small in both cases, not reaching 6 per cent.

The soil on which the potatoes were grown is rich in potash, lime, and phosphoric acid, and fairly well supplied with nitrogen.

DRAFT UPON THE SOIL INGREDIENTS.

The following, based upon the analysis of the ash, shows, in tabular form, the amounts of the important ingredients withdrawn from the soil by a crop of sweet potatoes, and which, except in the case of very rich soils, must soon be replaced by fertilization. By way of comparison is added the corresponding quantities of the same elements of plant food extracted from the soil by a crop of Irish potatoes:

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TABLE V. INGREDIENTS WITHDRAWN FROM THE SOIL BY POTATOES.

	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
Sweet potatoes—				
Crop of 1,000 lbs.	10.80	6.28	1.75	3.00
Crop of 5,000 lbs.	54.00	31.40	8.76	15.00
Irish potatoes—				
Crop of 1,000 lbs.	10.00	6.09	1.83	3.40
Crop of 5,000 lbs.	50.00	30.45	9.15	17.00

The amount of potash withdrawn by an average crop of sweet potatoes is thus seen to be about 31 pounds, as against 15 of nitrogen and 8.75 of phosphoric acid. When fertilization is required, the last two named ingredients will probably be the first to be replaced, not because they draw so heavily on the soil, but for the reason that the majority of soils in California have low percentages of phosphoric acid and nitrogen, and high contents of potash.

The figures given for the Irish potato show that while the total amount of mineral matter is, for the same weight, slightly lower than that for the sweet potato, yet the number of pounds of potash extracted is about the same. The amount of phosphoric acid, on the other hand, is a little more than that withdrawn by the sweet potato. The draft upon nitrogen by the Irish potato is somewhat heavier than that caused by the sweet potato.

When we shall be able to compare the analyses of Irish potatoes grown in California with the corresponding data for sweet potatoes, the above conclusions may be somewhat modified.

ANALYSES OF FIGS AND FIG SOILS.

(*Experiment Station Bulletin No. 102.*)

The growing importance of the fig industry in California calls for a full investigation of this fruit, in order to determine as quickly as possible the peculiarities of each variety as grown in the different sections of the State, and thus to gain an insight into their probable commercial adaptations, as well as their nutritive values. In accordance with this plan, already outlined and exemplified with respect to other fruits in Bulletins Nos. 93, 97, and 101 of this Station, such figs as were obtainable of the crop of 1892 have been examined and are here reported upon. The comparatively limited number of samples received thus far does not justify an extended discussion of the practical bearings of the results; yet the fact that they embrace a few of the most important varieties, as well as a number of new ones grown at the University Experiment Stations, lends interest to them. Marked differences will be noted, particularly as regards the proportions of juice, sugar, and acid, as well as in the nitrogen contents which so essentially determine the nutritive value; points of direct importance to the grower as well as to the consumer. The farmer is also specially interested in the amount and kind of ash ingredients and nitrogen taken from the soil by the fruit, since these represent what sooner or later will have to be replaced by fertilization, according to the character of the soil selected for the orchard. In this connection the result of the examination of typical soils that for ages have been used in the production of the best figs of commerce presents great interest, since we are thus enabled to compare them with those of this State that have been, or are likely to be, used in fig-growing, thus gaining a definite basis for their selection.

Producers of these fruits are again invited to communicate with the Station in regard to the examination of their product during the coming season. (E. W. H.)

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ANALYSES OF FIGS.

By Geo. E. Colby.

During the season of 1892 eleven varieties of figs were received from several localities in the State and submitted to analysis, the results being given in Bulletin No. 102 of this Station. In 1893 thirty other samples were received and analyzed, and the results are here incorporated with the former. The following is a description of the samples received during both seasons:

Crop of 1892.

No. 1. *White Adriatic*, from Fresno. The name of the grower was not obtained. The sample was received on August 19th in good condition. Its color was greenish-yellow, the fruit very tender, fairly juicy, and very sweet. It is a typical fruit of this kind.

No. 2. *White Adriatic*, from Kern County. It was grown by George A. Raymond. The sample was received in excellent condition on September 2d. A large fruit with an almost cream-yellow color, delicate, juicy, and very sweet fleshed. On page 235 will be found a description and analysis of the soil upon which these figs were grown.

No. 3. *Smyrna* (?), from Solano County. It was grown by E. R. Thurber, and the sample received on August 6th in good condition. It was a medium-sized fruit, of a dark-yellow color, and not very tender or sweet fleshed.

No. 4. *Smyrna "Bulletin,"* from Tulare County. The sample was grown at the San Joaquin Valley Experiment Station, and received on August 17th. It was a smaller but sweeter fruit than No. 3 from Solano County. Its flesh was coarse, but the color good. This fig was from young trees and marked as frost-proof.

No. 5. *California Black*, from Solano County. The sample was grown by E. R. Thurber, and was received in good condition on August 6th. A medium-sized fruit with coarse flesh and rather tough skin; not very sweet to the taste.

No. 6. *Hirtu du Japon*, from Tulare County. The sample was grown at the San Joaquin Valley Experiment Station, and received on August 17th in only fair condition. It was of medium size, with purple color; its flesh was white in color, tender, juicy, and quite sweet. The sample was from young trees, which are prolific bearers and frost-proof.

No. 7. *Constantine*, from Tulare County. The sample was grown at the San Joaquin Valley Experiment Station, and received in good condition on August 17th. It was small in size and with a striped green and purple color. Its flesh was hard and fibrous, but quite sweet. The sample was from young trees and is another of the frost-proof varieties of the station.

No. 8. *Du Roi*, from Tulare County. It was grown at the San Joaquin Valley Experiment Station, and was received on August 17th in good condition. It was fully ripe and had a cream color, but its flesh was hard and rather dry, though quite sweet in taste. This is a new variety, which also has proved its ability to withstand frost. The sample was from young trees.

No. 9. *Dorée Narbus*, from Tulare County. The sample was from young trees grown at the San Joaquin Valley Experiment Station, and

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was received in good condition on August 17th. The fruit was very small, and when received its flesh was dry and tough, although very sweet. This variety is also frost-proof, the hardiest of fifty-four varieties at the station.

No. 10. *Pasteliere*, from Tulare County. The sample was received from the San Joaquin Valley Experiment Station on August 17th in only fair condition. It was small in size, with a fibrous and rather tough though quite juicy and sweet flesh. It also was from young trees and of a frost-proof variety.

No. 11. *Brunswick*, from San Luis Obispo County. Grown by Sinsheimer Bros., and received on October 25th. This was a very large fig of dark color. Its flesh was tender, juicy, and very sweet.

Crop of 1893.

No. 35. *White Adriatic*, from Amador County. Grown at Foothill Experiment Station, near Jackson, Amador County. Sample received September 16, 1893, in fair condition. Somewhat smaller than the same named fruit from other localities; shape regular, nearly flat above, stem short; outside flesh greenish-yellow, inside flesh light pink; taste very sweet and rich.

No. 37. *White Adriatic*, from Fresno County. Grown by F. Roeding; received September 27, 1893. A large fruit of nearly oval shape; body of light yellowish-green color, stem end cream colored; stem short and thick; flesh firm and solid, deep pink in color and very sweet.

No. 34. *Dalmatian*, from Tulare County. Grown at Tulare Experiment Station plot. Sample received August 16, 1893. Rather irregularly shaped, one side round, the other bulging. Skin pale brown in color, dry and tough; flesh golden yellow in color, delicate, and melting; a delicious fruit.

No. 36. *Hirtu du Japon*, from Tulare County. Grown at the Foothill Experiment Station, near Jackson, Amador County; received on September 16, 1893. Almost turnip-shaped, with purple skin; firm flesh, of purple color outside, cream colored on the interior; not very sweet. Stalk only of medium length.

No. 30. *Hirtu du Japon*, from Tulare County. Grown at Tulare Experiment Station; received August 15, 1893. A very much larger fruit than that received from Jackson, more nearly round in shape, and had characteristic long, thick stalk; color of skin mostly purple, shading into cream at stalk end; flesh was straw colored, delicate, juicy, and sweet.

No. 31. *Constantine*, from Tulare County. Grown at the Tulare Experiment Station; received August 15, 1893. Fruit full-fleshed, nearly round, but flattened at the apex; stem thick and short, body grayish-purple, running into pale cream toward stalk; flesh dryish and deep pink color.

No. 27. *Du Roi*, from Tulare County. Grown at Tulare Experiment Station; received on August 10, 1893. A pale yellow colored and large fig, with solid flesh of pale straw color.

No. 19. *Pasteliere*, from Tulare County. Grown at Tulare Experiment Station; received August 19, 1893. A medium-sized fruit of fair sweetness.

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No. 13. *Brunswick*, from Fresno. Grown by F. Roeding, and received July 5, 1893. Fruit full-fleshed; condition excellent; color of skin purple; flesh tender and melting.

No. 12. *San Pedro* (*White*), from Fresno. Grown by F. Roeding; received on July 5, 1893. Condition excellent; fruit large, with yellow-colored body, shading into green at stem; skin thick.

Nos. 14 and 15. *Grise*, from Fresno County, first and second crop. Grown by F. Roeding. No. 14 was received on July 14, 1893, and was brownish-red in color, with very tender flesh. No. 15 was received on August 12, 1893, and was full-fleshed, grayish-brown in color, with rich, tender flesh of quite red color.

No. 17. *Brown Turkey*, from Mission San José, Alameda County. Grown by Professor Hilgard. Color of fruit brown; elongated in shape; flesh juicy and fairly sweet.

No. 26. *Brown Ischia*, from Tulare County. Grown at Tulare Experiment Station; received on August 10, 1893. Fruit flattish-round shaped, pale brown at apex shading into yellow at stem; flesh pale pink in color and of medium sweetness.

Nos. 16 and 39. *Black Mexican*, from Fresno, first and second crop. Grown by F. Roeding. No. 16 (first crop) was received on July 14, 1893, and was dark purple in color, fully ripe, and much larger than the second crop sample. No. 39 (second crop) was received on September 27, 1893. Nearly egg-shaped, short-stemmed, hollow; flesh firm, of reddish-brown color and medium sweetness.

No. 18. *Abondance precoce*, from Tulare County. Grown at the Tulare Experiment Station; received August 7, 1893. Fruit small, brown colored at apex, cream colored at stem end.

No. 23. *Coucourelle blanche*, from Fresno. Grown by F. Roeding; received for analysis August 8, 1893. Skin rather tough; fruit very small and flattened; color pale yellow to green.

No. 25. *Coucourelle noire*, from Fresno. Grown by F. Roeding; received August 8, 1893. A small brownish-purple fig, with delicate skin and medium juicy flesh.

No. 24. *Rose blanche*, from Fresno. Grown by F. Roeding; received for analysis August 8, 1893. Fruit full-fleshed, pyramid-shaped, of dark purple color; flesh juicy and very delicate.

No. 28. *White Celeste*, from Fresno. Grown by F. Roeding; received for analysis August 12, 1893. A very small pear-shaped fig, with very long stalk and pale-violet skin.

No. 29. *Cargigne*, from Fresno. Grown by F. Roeding; received on August 12, 1893. A flattened, roundish-shaped, full-fleshed fruit, with brown apex and cream-colored base; somewhat spotted; flesh juicy and pale pink in color.

No. 33. *Ravignon*, from Tulare County. Grown at Tulare Experiment Station, and received on August 16, 1893. A large fig, varying in shape, some being pear-shaped, some greatly bulged on one side. In color some were entirely cream-colored, others had brown spots and brown apices, with upper half of cream color. Stem thick and pretty long. Flesh was somewhat hollow, pale pink in color, and was sweet and juicy.

No. 32. *Col di Signora Bianca*, from Tulare County. Grown at the Tulare Experiment Station; received August 15, 1893. Apex flattened.

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body rounded, stem quite thick and short; color light maroon; flesh yellowish-pink in color, pretty juicy and fairly sweet.

No. 20. *Bellona*, from Fresno. Grown by F. Roeding; received on August 8, 1893. Medium-sized, nearly round, with thick stem; color dark purple; center of fruit dry and open; flesh sweet and palatable.

No. 21. *Marseilles*, from Fresno. Grown by F. Roeding; received for examination on August 8, 1893. Very small, irregular-shaped fig, flat on one side and elongated but roundish on the other; color beautiful golden yellow; leathery skin; flesh pink color and dryish.

No. 22. *Missonne*, from Fresno. Grown by F. Roeding; received for analysis on August 8, 1893. Regular roundish-shaped, full-fleshed fig, with medium thick stalk and dark, purple-colored, delicate skin; flesh juicy and pink in color.

No. 38. *Bourjassotte panachée*, from Fresno. Grown by F. Roeding; received September 27, 1893. Fruit large, stalk large and thick, roundish in shape mostly, some flattened on one side; color banana yellow, striped lengthwise with light green bars; flesh solid deep pink and very sweet and juicy.

No. 40. *Zimitzia*, from Fresno. Grown by F. Roeding; received for examination on September 27, 1893. Fruit was nearly round, with yellowish-green delicate skin, and short, quite thick stalks; flesh hollow and juicy, of pink color.

No. 41. *Cernica*, from Fresno. Grown by F. Roeding; received on September 27, 1893. Quite round, medium-sized, full-fleshed fig; skin thin and tough, of purple color marked with minute white spots; flesh sweet and blood-red in color.

DISCUSSION OF ANALYTICAL RESULTS.

The large table contains the results of the physical and proximate analyses of the figs of the crops of 1892 and 1893. We do not try to calculate averages, because we have so few analyses of like varieties, and also because most of the fruits are from young orchards. At the same time it is profitable to discuss these results somewhat, to make clearer some of the points embodied in the tables. The soils on which samples 4, 6, 7, 8, 9, and 10 were respectively grown are described on page 236.

Amount of Juice in the Fruit.—The juiciest fig thus far examined is Rose blanche, No. 24, from Fresno, with *90 per cent;* Missonne, No. 22, has 88.6 per cent juice, and Brunswick, No. 13, from Fresno, shows 86.7 per cent; then the other varieties fall away from these figures to from 75 to 70 per cent juice, till we reach the very dry ones. These are headed by Coucourelle blanche, No. 23, from Fresno, with only *38.5* per cent juice, leaving 61.5 per cent pressed "pulp"; Marseilles, No. 21, has 53.4 per cent juice. The "pulp," as reported, holds in it all the parts of the fig excepting the juice.

Amount of Sugars in the Fruit.—The Adriatics, Nos. 2, 35, and 37, from different localities, and Bourjassotte panachée, No. 38, appear to lead in this important ingredient, having as they do about 20 per cent of sugar. The Smyrna, No. 4, with 19.2 per cent, Rose blanche, No. 24, and Zimitzia, No. 40, both from Fresno, with 18.5 per cent sugar, follow, apparently, rather closely. Those figs showing a poverty in sugars are the California Black, No. 5, and Coucourelle blanche, No. 23, each having but 8 per cent; the Missonne, No. 21, is but little better off, as it

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shows only 11 per cent sugar. The bulk of the fruits analyzed run in the neighborhood of from 13.5 to 15.5 per cent sugar; for comparison with other varieties of California fruits the sugar has been averaged, with the result of 15.53 per cent for the forty-one samples studied. (See summary at the end of report on fruits.)

European data at hand do not give any report upon fresh figs, but from the German analyses of dried figs it is easy to calculate, approximately, that the sugar in the whole fresh fruit amounts to 20 per cent, thus showing no advantage over our largely grown White Adriatic figs in sugar contents.

The table below makes it evident that among California fruits, the *figs*, White Adriatics especially, hold no mean place in sugar contents.

Percentages of Sugar and Acid.

No. Analyzed.	Fruits.	Juice.		Flesh.	Whole Fruit.
		Acid—Per Cent.	Sugar.	Sugar.	Sugar.
4	Figs, White Adriatic	.21	19.70		19.20
37	Other figs	.10 to .20	10.0 to 29.0		8.0 to 19.20
11	Apricots	.68	13.31	11.93	11.10
13	French prunes	.31	23.69	19.70	18.53
3	Plums	.48	17.97	13.25	12.80
2	Peaches	.24	17.00	13.40	12.50
---	Grapes	.50	24.00	23.00	20.70
80	Oranges	1.28	10.68	7.12	5.40

The *acid* of the figs (expressed in terms of sulphuric (SO_3) for the sake of comparison) seems thus to be very much lower than that found in any of our other fruits.

Nutritive Values—Nitrogen Contents.

The *maximum* nitrogen percentage is 0.414, corresponding to 2.587 per cent albuminoids (proteins) found in Marseilles, No. 21; White Adriatic, No. 2, with 0.36 per cent nitrogen, or 2.256 albuminoids; Dalmatian, No. 34, with 0.308 per cent nitrogen, equivalent to 1.935 albuminoids, and Pasteliere, No. 19, with 0.292 per cent nitrogen, or 1.825 albuminoids, all indicate too great richness.

The *minimum* amount, 0.116 per cent nitrogen, or 0.725 albuminoids, is yielded by White Adriatic, No. 1. Again, for comparison with other California fruits, the average was made for the albuminoids in the figs, and we give 1.522 per cent for the figure. It is used in the table in the summary of this fruit report, showing the amount of *nutrients* in different varieties of fruits.

Without repeating what has been already published by this Station in its fruit bulletins, Nos. 93, 97, and 101, relating to the importance of the *flesh-forming ingredients* (*albuminoids*) of our fruits, we give below, in tabular view, the average amounts of these substances contained in some of the fruits we have examined and considered; added to this are such data from European sources as are at hand.

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Average Percentages of Albuminoids.

Fruits.	Number of Analyses Made.	In Whole Fruit—Total.	Calculated to Whole Fresh Fruit.	
			In the Fresh Flesh, or Edible Portion.	In Fresh Pits or Rind.
Figs.				
California	28	1.522	(1.50)	
European		1.420	(1.42)	
Oranges.				
California	35	1.140	.760	.380
European (Sicilian)		1.780		
Apricots.				
California	11	1.250	1.088	.162
European		.490		
Prunes.				
California	20	1.012	.837	.175
European		.780		
Apples and Pears.				
European		.375		

As heretofore pointed out in Bulletin No. 101, the fig rates *first* in flesh-forming materials among our fruits; apricots and plums, *second;* prunes and oranges, *third.*

Comparison with Dried Fruits.

It is interesting to reproduce, at this point, a summary of the *food constituents* of some of our dried fruits as compared with the dried fig—results already published in Bulletin No. 101. In addition, the analysis of a sample of California raisin is here reported:

Percentage Composition of Dried Fruits.

Contents.	French Prunes, Dried. Edible Portion.	Apricots, Dried. Edible Portion.	Raisins, Muscats.*	Figs, White Adriatic.	Figs, Smyrna (Imp'ted).†	Apples, European.
Water	25.20	32.44	18.95	25.00	21.06	33.00
Ash	1.50	1.38	1.55	2.24	1.80	1.40
Albuminoids (crude protein)	2.80	2.90	4.00	4.50	4.06	1.70
Crude fiber	}					8.30
Nitrogen-free extract	29.77	32.18	2.30	10.11	10.18	21.60
Fat	}					
Sugar	40.53	29.59	72.50	57.60	62.50	32.00
Free acid, calculated as sulphuric (SO_3)	.40	1.51	.70	.45	.40	2.00
Totals	100.00	100.00	100.00	100.00	100.00	100.00

* Samples from the vineyard of R. H. Loughridge, Woodland, Cal.
† Analyzed at this Station.

As stated in previous fruit bulletins, these results are too meager to serve as the basis for a general discussion of the relative food values of the fruits examined. However, we note some wide differences among the nutrients. For instance, the sugars and albuminoids, or crude pro-

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tein, show considerable variation; the apricots, like the apples, yielding less than one half as much sugar as the Muscat raisin, which contains nearly twice as much sugar as the prunes, and one and one quarter times as much of that substance as the fig. European analyses of raisins show figures for sugar contents which differ but little from those we give here. Both raisins and figs, with, respectively, 4 and 4.5 per cent albuminoids (flesh-forming materials), stand from one and one half to two times above the other fruits in this respect. The fig yields nearly twice as much ash as the other fruits here reported.

ASH COMPOSITION AND NITROGEN CONTENTS.

In the large table (A) we see the highest ash percentage, viz., 1.16, in Marseilles, No. 21—over twice as much as we have found the average (.577 per cent) to be of twenty-eight samples of figs. The small table (B) shows no greater variation in the composition of the ash than was to be expected.

According to previous bulletins relating to fruits (Nos. 93, 97, and 101), the fig stands *second* in amount of mineral matter withdrawn from the soil, for equal weights of the various fruits. From European data we place grapes *first* in this respect, and from our own findings the orange, lemon, prune, apricot, and plum, *third*. We report in the large table on page 229 an ash analysis of the White Adriatic fig from Kern County, and as the figures there represent a considerable district we can take them as a fair guide, the analysis of the ashes of other fruits from different localities of California having shown that the variations will not be great enough to vitiate the conclusions. But few European analyses of fig ashes are at hand, and their great discrepancies necessitated an analysis by us of the ash of an *imported* fig. The results obtained are given in the accompanying tables, and it will be noted that the figures agree, within the limits to be expected, with those we report for our figs. Thus we are able to correct the data, given in Bulletin No. 101, relating to European fig ashes.

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B. ANALYSIS OF THE ASH OF THE FIG.

Whole Fruit.	Place of Production.	Sender, or Origin.	Percentage of Pure Ash	Composition of the Pure Ash.												
				Potash	Soda	Lime	Magnesia	Peroxid of Iron	Brown Oxid o Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less excess of Oxygen due to Chlorine	Total
No. 2. White Adriatic.	Miramonte Kern Co.	Geo. A. Raymond.	.897	60.13	1.17	9.12	5.32	.84	.19	11.07	4.75	4.85	2.55	99.99	.63	99.36
No. 37. White Adriatic.†	Fresno	F. Roeding	.493	55.43	1.58	13.40	5.66	1.34	.22	12.34	3.29	4.24	2.49	99.99	.62	99.37
No. 34. Dalmatian†	Tulare Expt. Station.	Univ. of Cal.	.657	51.94	4.40	10.18	5.83	4.40	.23	14.87	3.68	3.83	1.11	100.47	.28	100.19
Smyrna *	Asia Minor	Imported		48.60	2.20					11.20						

* Analyzed at this Station. † Analyzed with assistance of Mr. Bioletti, of this Station staff.

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Draft on Soils by Various Crops.—The following small table gives the amounts, in pounds, of vital soil ingredients extracted by the different fruit crops (for fruit alone) that will have to be replaced by fertilization. Bulletin No. 101 gives more data relating to European fruit than we need for the present discussion:

Soil Ingredients Extracted by Different Fruit Crops.

Fruits.	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
Figs.				
Europe*—				
In each 1,000 pounds	8.00	3.89	.89	2.27
Crop of 15,000 pounds	120.00	58.35	13.35	34.05
California (White Adriatic)—				
In each 1,000 pounds	7.81	4.69	.86	2.38
Crop of 15,000 pounds	117.15	70.45	12.90	35.70
Grapes.				
Europe—				
In each 1,000 pounds	8.80	5.00	1.52	1.70
California Apricots.				
In each 1,000 pounds	4.91	2.90	.64	1.74
Crop of 30,000 pounds	147.30	87.00	19.20	52.20
California Prunes.				
In each 1,000 pounds	4.86	3.10	.68	1.62
Crop of 30,000 pounds	145.80	93.00	20.40	48.60
California Oranges.				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60

*Imported—analyzed at this Station.

With the exception of the grape, it seems that the fig draws rather more heavily upon the mineral ingredients that will need to be replaced by fertilization than do any of the other fruits we have examined; following closely the amounts taken up by the grape and fig of foreign growth. Apricots and prunes, like the oranges, do not in any case draw nearly so heavily upon the mineral matters as the fig; lemons and plums, however, very nearly approach it. And among the figs we note that the White Adriatic stands somewhat above the other figs in this respect. As to nitrogen, it is readily seen that among our fruits the figs, on the whole, draw decidedly the highest amount, and are quite like those of foreign production in this regard. Here, again, the White Adriatic appears to lead.

Potash.—In the ashes of the fig, as in the prune, apricot, orange, and lemon, we find potash to be the leading ingredient, amounting to about three fifths of the whole ash. From the partial ash analysis, given above, of the imported Smyrna fig, we find the potash to be four fifths as much as is contained in the ashes of figs of California growth. We may, however, say for the fig, as for other California fruits, that although potash constitutes so large a portion of the ash of these fruits, its replenishment to the soil will be delayed long beyond the addition of other fertilizing ingredients, because most California soils are naturally so well stocked with it that available potash for the current demand will be adequately supplied for many years.

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It will be noted below in the soil discussion that the average percentages of potash for both California and Asia Minor soils is nearly identical.

Phosphoric Acid.—The fig, like the lemon, appears to range a little below the other fruits in its draft upon this material, for we find the ashes to stand in the following order in their phosphoric acid percentages, viz.: Prunes, 14.1; apricots, 13.1; oranges, 12.4, and lemons and figs, 11.1. The European data relating to this subject give for phosphoric acid a figure about the same as that we have obtained for our figs. Since our soils usually contain a very limited supply of phosphoric acid, on the average only about one fourth that given below for Asia Minor soils, our fig, as well as prune, apricot, and orange orchards, will require *phosphatic* fertilizers first.

Nitrogen.—As above stated, the fig leads among our fruits in its demand upon the soil for this substance, apricots only coming near it in this respect. Thus we find that, for the southern localities especially, the same necessity of early replacement of nitrogen in figs and stone fruit as for orange orchards, and partly for the same reason, viz., that California soils are usually not rich in their natural supply of this substance; however, they contain about double that found in the Asia Minor soils, as indicated by the *humus*.

Lime.—Of the other ash ingredients, the lime in the fig ranges about twice that in the prune, and three times that in the apricot, while the orange and lemon show some two and one half to three times more. As our soils usually contain plenty of lime, even for oranges, only in exceptional cases would there be any necessity of replacing this ingredient by fertilization.

FIG SOILS.

By M. E. Jaffa.

It is not intended to make a complete discussion of fig soils, but merely to present the analyses of the soils from the Asia Minor districts, whence comes the Smyrna fig of commerce; and by way of comparison, we give some analyses of typical soils from different regions in this State where fig culture seems to succeed.

With the exception of the analysis of soil No. 1466, from Miramonte, Kern County, published here for the first time, all the descriptions, analyses, etc., of the California soils are taken from previous reports of this Station.

Unfortunately, we have for the Asia Minor soils no data regarding the area which each soil analyzed represents, the depth of the soil, distance to water, the natural growth, etc.

Asia Minor Soils.

A. *Soil from Smyrna*, Asia Minor; received at the University May, 1891, with some fig cuttings, imported by the U. S. Department of Agriculture. It is a calcareous loam, dark gray in color; somewhat plastic on wetting and kneading; contains fragments of limestone, together with considerable fine quartz gravel.

B. *Soil from Erbelli*, Asia Minor; said to grow the finest commercial figs. The sample was sent by Geo. C. Roeding, of Fresno, Cal. This is

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a micaceous sandy soil, of light buff tint, does not become plastic on wetting and kneading, and consists almost entirely of fine earth. It shows effervescence with acids.

C. *Soil from Erbelli*, Aidin District, Asia Minor. The sample was sent by D. Van Lennop, Auburn, Cal. It is a sandy gravelly loam, light in color; shows no plasticity upon wetting and kneading. The soil contains quite a large amount of coarse gravel and does not effervesce upon the addition of acids.

California Soils.

No. 1466. *Sandy loam soil*, from S.W. ¼ of Sec. 17, T. 26 S., R. 23 E., Miramonte, Kern County; sent by Geo. A. Raymond. It consists almost entirely of fine earth; the original vegetation was tar weed and pepper cress. It is of a dark buff tint, becoming somewhat plastic on wetting and kneading. Mr. Raymond writes, under date of September, 1890, regarding this soil:

"Top soil from fig orchard, a quite large streak running from southeast to northwest, and comprising about two hundred acres. Everything does well in this soil, even when new and without previous cultivation. The growth of weeds last spring was tremendous. The figs (White Adriatic) are now in the third year from the nursery, with trunks from 4 to 6 inches in diameter, and corresponding tops. The trees have made a heavy growth this year, though setting but little fruit. The soil bakes hard when flooded, but is tillable when moist."

The analysis of this soil shows it to contain high percentages of potash, lime, and phosphoric acid, the latter approaching very nearly to three times the average for California soils. The nitrogen, as indicated by the humus, is in fair supply.

No. 1159. "*Sandy soil*, from the Experiment Station tract, near Tulare City. It is of a buff tint, quite sandy, not assuming any plasticity on wetting and kneading, and capable of tillage at all times. Originally timbered with scattering but large white oaks. Sample was taken to the depth of 12 inches; at 18 to 20 inches the color changes slightly toward yellowish, but the texture continues unchanged; at 36 to 40 inches there underlies a more compact material or hardpan, fairly coherent, and of somewhat finer texture, preventing leachiness. It effervesces with acid."

This soil, as may be seen from the analyses given in the table below, is rich in potash and lime, and contains an adequate supply of phosphoric acid. It is very low in humus in the spot sampled, but doubtless this is not the case throughout, judging from the appearance of the land. Its high percentage of soda tells of the vicinity of alkali spots. So far as can be judged, this soil is fairly representative of the higher portion of the sandy plains generally from Kern to Stanislaus County.

No. 570. *Alluvial soil*, 12 inches; from the Eisen vineyard, Fresno County. It is reddish-brown in color, only moderately heavy, with much coarse sand intermixed; and easily tilled, except when very wet. This soil represents the alluvium of the minor streams heading in the foothills. The phosphoric acid in this soil is very low; but this deficiency is in some respects modified by the great depth and perviousness of the soil. The supply of lime is abundant, and that of potash above the average.

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Nos. 971 and 972. *Dark gravelly loam soil and subsoil*, from the vineyard and orchard of Mr. J. A. Sladky, Mountain View, Santa Clara County.

The soil is a mouse-colored clay loam, intermixed with a good deal of gravel; some of the latter quite coarse, and both rounded and angular. The lumps of dry soil can be crushed between the fingers with some difficulty, and on wetting it becomes only moderately adhesive.

This soil represents the extreme western edge of the sloping, gently rolling plain that forms the western portion of the Santa Clara Valley, southward of Mountain View. Along the streams the soil is of great depth, sometimes showing hardly a perceptible change for 12 or 15 feet in depth, and the roots of trees are found penetrating freely to such depths in the gravelly material. This great depth, perviousness, and perfect drainage would constitute alone no mean advantage, if the soil were only of moderate fertility. But the analyses show a very good supply of plant-food. The potash, lime, and humus are high, and the phosphoric acid is found in very fair amounts. It is true that these percentages apply to only one half of the soil-mass, the rest being gravel. But the great depth and easy permeability of the soil more than make up the difference, in comparison, *e. g.*, with an adobe soil of similar composition.

These soils may be considered as well adapted to the production of almost any fruit consistent with the local climate.

No. 110. *Soil of Putah Valley*, near Dixon, Solano County; sent by Mr. J. M. Dudley, from the "middle land" of the plain, on the slopes of the swales, about 3 feet above the lowest land. Depth taken, 12 inches.

This soil is representative of the rich alluvial plains of Yolo and Solano Counties, the soils of which are of prominent fertility, being a mixture of the finest natural sediments of the Sacramento River, with those carried by the streams heading in the volcanic portion of the Coast Range (of which Cache and Putah Creeks are the chief). The plain is scarcely broken by the slight swales or undulations coming down from the foothills; but the region is thickly settled and is largely occupied by orchards and vineyards. The analysis of this soil confirms the experience stated above, relating to the fertility of the soils of this section. The amount of potash is large, and that of lime and phosphoric acid adequate.

No. 766. *Granite soil*, from near Loomis (formerly Pino Station), Central Pacific Railroad, Placer County; sent by E. W. Maslin, of Sacramento, who thus describes the soil:

"There are about 80 square miles of such land lying between Boulder Ridge and the North Fork of the American River, and between Roseville on the south and Auburn Ravine on the north. The ground is gray when dry; when damp, it is brown or reddish. In places the soil is from 9 to 10 feet deep, in some places not over one foot. The subsoil also varies in depth and character; on the hills it rests on a red, rotten granite, into which the roots of trees and shrubs penetrate. It has been dug with the pick to the depth of 20 feet. In the valleys there underlies a gritty clay, here called 'cement,' but also penetrable by roots. Water is within 10 to 12 feet of the surface of the hills in summer. The natural growth is live oak, white oak, digger and nut pine, chaparral 8 to 10 feet high, abundance of poison oak, and California holly. The growth

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of the fig tree is very satisfactory. I do not irrigate, and my observation is, that the fig tree *as a producer* of first-class figs does better in the foothills than in the valley. Where the soil is too rich the tree is apt to overgrow and go to wood instead of fruit."

The hill soil, which seems to be a typical one, is a reddish-gray sandy loam, the sand mostly coarse, and consisting largely of granitic debris; it should till easily at all times. The subsoil below the depth of 12 inches is somewhat lighter colored and more sandy. The soils from the depression or valleys seem to differ from the hill land mainly in being somewhat heavier and also of a darker tint.

No. 764. *Valley soil*, from same locality as No. 766. A brownish, dun-colored, rather sandy loam, darkening materially on wetting, and becoming but slightly plastic. Contains much coarse granitic debris. Sample taken to depth of 12 inches.

The subsoil of this land is more reddish and somewhat sandier than the surface soil, the sand being decomposed micaceous granite, increasing downward. Beneath the subsoil, at depths varying from 3 to 10 feet, is a porous, sandy hardpan (cement), quite coherent from clayey binding material, and not readily penetrable by roots. Beneath this comes "rotten" granite, sometimes to 20 feet depth, in which the feldspar masses are kaolinized.

These two granite soils show the usual large amount of inert material (granitic sand or debris), which naturally depresses the plant food percentages. The valley soil differs from that of the ridges, as might be expected, in somewhat higher percentages of lime—of which substance, however, there is enough in both—and of phosphoric acid, of which the supply is small in both, and will doubtless be the first deficiency to be supplied. Potash is present in adequate amounts, and humus is in fair supply, especially in the valley soil, causing the higher absorption of moisture as compared with the ridge soil. In both, however, that factor is low; hence, irrigation would doubtless be very beneficial to the thrifty growth of the crops. The somewhat slow progress of vines and trees in the granitic soils of the foothills is at many points a matter of popular remark and complaint.

No. 51. *Red surface soil*, from near Auburn, Placer County, taken 12 inches deep; sent by Mr. N. S. Prosser, of Auburn. Original vegetation: oak, pine, manzanita, and chaparral.

This is a fair sample of the red soil of the placer mines, which seems to contain a small amount of gold everywhere, and has been washed on a small scale ever since the discovery of gold in California. It is of a dark, orange color, rather light in tillage, and pulverulent when dry, forming a very fine reddish dust. It contains throughout numerous fragments of slate, more or less decomposed, of all sizes, and is usually underlaid by the same, or its debris, at a variable depth, rarely less than several feet, unless lying on steep slopes. The soil becomes slightly plastic on wetting, and can be worked soon after rains; its color darkens considerably on wetting. When dry its lumps are easily crushed between the fingers.

The Auburn soil, a typical slate one, differs from the granitic soils of Pino in one very essential respect: it has on the ridge land over five times as much phosphoric acid as the soil, and four times as much as the subsoil, derived from the granite. In other respects it does not differ widely, except that it contains much less inert matter, as indicated by

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the insoluble matter. But its well-known high production, both in quantity and quality, and its thriftiness, confirm the forecast given by the analysis. Practically the same soil prevails near Newcastle, and to the southeast of Penryn, all localities noted for the production of fine shipping fruits.

It will be seen from an inspection of the analyses of the Asia Minor soils that they are all exceedingly well supplied with lime and phosphoric acid, and in the case of soil B from Erbelli district, notably also with potash. This latter soil appears, apart from the humus contents, to be the richest, with its 1.09 per cent of potash, 1.96 of lime, and 0.29 per cent of phosphoric acid. It does not contain as much lime and phosphoric acid as soil A from Smyrna, which shows 4.44 per cent and 0.37, respectively, but the potash percentage is just double that found in soil A, and figs draw quite heavily on this very important ingredient. The Erbelli soil B has another very striking advantage over both the others, in that while the latter have 35 and 40 per cent, respectively, of coarse material, it has only 1 per cent of these.

The percentages of potash and lime in the Erbelli soil C are somewhat below those of the other two, while in phosphoric acid it rates the same as B.

When comparing the nitrogen contents as indicated by the humus percentages, we note a marked deficiency in soil B, with only 0.27 per cent. The figure for soil C, 0.44, about one and two thirds times that of soil B, is only fair; and in soil A, showing nearly three times as much humus as does soil B, is satisfactory.

The moisture absorption coefficients are low in both soils B and C, and only fair in soil A. The highest factor in A was to be expected, owing to its rating so much ahead of the other two in humus.

The comparison of the analyses of the Asia Minor soils with those from this State, shows very strikingly the richness in phosphoric acid of the former over the latter. The lowest per cent of this ingredient in the Asia Minor soils, 0.29, found in soil B, from Erbelli, is more than one and one third times as much as the highest (0.22) shown in the soil No. 1466, from Miramonte, of the California soils; and the average, 0.32 per cent, of the three Smyrna soils is almost exactly four times the average for *all* California soils examined (about two hundred in number), and nearly three times the figure, 0.113, representing the average of phosphoric acid for four hundred and sixty-six soils of the humid region (east of the Rocky Mountains) of the United States.

With reference to lime, the average for the Asia Minor soils is 2.60, as against 1.08 for California. The figures, 0.690 for Asia Minor, and 0.644 for California, representing the averages for potash, show that both sets of soils are about equally well supplied with this element of plant-food.

A marked difference, in favor of California soils, is at once seen when the humus percentages are compared. The average for the Asia Minor soils is only 0.47, being less than one half that, 1.08 per cent, found for the average of one hundred and ninety-eight California soils.

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Below is a tabular view of the averages just discussed:

Average Percentages of the Important Ingredients in Soils of Arid and Humid Regions.

	Arid.		Humid.
	California. Average of 198 Soils.	Asia Minor. Average of 3 Soils.	United States, East of Rocky Mountains. Average of 466 Soils.
Potash	.644	.690	.216
Lime	1.078	2.600	.106
Phosphoric acid	.083	.320	.113
Humus	1.040	.470	2.390

The above little table conveys another forcible illustration of an arid region showing far greater amounts of potash and lime in its soils than does a humid one.

ANALYSES OF CALIFORNIA ORANGES AND LEMONS.

By GEORGE E. COLBY.

The data here given comprise descriptive notes upon citrus fruits of the crop of 1893, together with tabulated proximate analyses of twenty samples of oranges, and nine samples of lemons of the same year. A portion of the work (averages) already published will also be found herein as indispensable for comparison; and the whole a continuation of the work presented in Bulletin No. 93 of this Station. It will be of interest to note that we give here, for the first time, some analyses of oranges and lemons grown, or raised, on *sour stock* (*Citrus bigaradia vulgaris*), viz., Washington Navels, St. Michaels, Malta and Ruby Blood oranges from Riverside, and Royal Messina and Villa Franca lemons from Nordhoff and South Riverside, respectively. Other new items are the analyses of the Jaffa, Star, Parson Brown, Du Roi, and Pineapple oranges.

ORANGES.

Description of Samples Received (Crop of 1893).

(For description of oranges of the crop of 1891 received, see Agricultural Report, 1890, pages 107–109, or Bulletin No. 93; for crop of 1892, see Report for 1891–92, pages 99–101.)

No. 75. *Navel*, from Riverside, San Bernardino County. Grown by T. P. Edwards. The sample is from a lot that was awarded the second premium at the State Fair at Colton, and was produced on sour stock. It was received here on March 27th. Fruit was medium in size, rounded in shape, with the thickish skin separating very readily from the flesh; the cell structure of the flesh, while somewhat coarse, was still very crisp and juicy; the taste and flavor were excellent.

No. 91. *Navel*, from Riverside, San Bernardino County. Grown by T. P. Edwards, and not exhibited at the fair. The sample was received on April 27th. There was no difference between this and the earlier sample, save that the skin of the later clings more closely to the flesh;

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the juice was very sweet. Mr. J. E. Cutter, through whom we obtained these oranges, writes on April 8, 1893: "We do not assert that the fruit is necessarily better on sour stock, but only that it *will bear comparisons.*"

No. 68. *Navel*, from Porterville, Tulare County. Grown by George Frost. The sample was received on March 3d in good condition, with high color. The skin and "rag" were heavy and very thick; the flesh coarse, but quite tender and juicy, and with a very agreeable taste.

No. 74. *Seedling*, from Porterville, Tulare County. The sample was grown by J. W. Prettiman, and received on March 3d. This was a fruit of high color, large size, and fine appearance, with a thick skin and "rag," somewhat coarse and tough flesh, well-developed seeds, and tart yet very sweet juice.

No. 77. *Mediterranean Sweet*, from Colton, San Bernardino County. Grown by A. S. Fox, and is from a lot that was awarded the first premium at the State Fair at Colton. The sample was received here on March 27th in very good condition. It was of the usual size and somewhat elongated in shape; the skin and "rag" fairly thin, the flesh coarse structured but juicy, and the seeds few and poorly developed.

No. 72. *Mediterranean Sweet*, from Porterville, Tulare County. The sample was grown by George Frost, and received on March 3d. It had a high color, very thick skin and "rag," and a watery taste.

No. 81. *St. Michael*, from Colton, San Bernardino County. The sample was grown by James Barnhill, and is from a lot that received the first premium at the State Fair at Colton. The sample was received on March 27th. It is an orange of fine appearance, with a thin lemon-yellow colored skin, which separates very easily from the pulp. The flesh was not very tender, but quite tart and pleasant to the taste.

No. 76. *St. Michael*, from Riverside. Grown by J. E. Cutter on sour stock. The sample was received for analysis on March 27th. It was a typical orange of its kind—very thin skinned; the seeds few, but very well developed; the flesh very tender and juicy.

No. 71. *St. Michael*, from Porterville, Tulare County. Grown by J. W. Prettiman, and received on March 3d. It had a high color; a skin thick for the variety, but not heavy; juicy and tender flesh, and well-developed seeds.

No. 79. *Malta Blood*, from Riverside. Grown by T. P. Edwards. The sample was taken from a lot that received the second premium at the State Fair at Colton. It was raised on sour stock, and the samples were received on March 27th, in good condition. They varied in shape, one being well rounded and the other elongated in shape. They were of the average size, with a thick skin and "rag," easily and cleanly separated from the flesh; the flesh was of very fine texture, tender and juicy; the juice very red, much more colored than that of the Ruby Blood (No. 78); the seeds were abortive.

No. 73. *Malta Blood*, from Porterville, Tulare County. Grown by George Frost. The sample was received on March 3d. It had a high color, thick skin, juicy but coarse-textured flesh, and a juice only just red-colored.

No. 78. *Ruby Blood*, from Riverside. Grown by J. E. Cutter. The samples were raised on sour stock, and received for analysis March 27th. They had a deep reddish-yellow skin; the "rag" and skin were heavy and thick; the flesh and juice pale red in color, and of coarse texture, but tender and juicy; the seeds few and poorly developed.

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No. 69. *Ruby Blood*, from Porterville, Tulare County. Grown by Geo. Frost. The sample was received on March 3d. It was highly colored, and had a thick skin and heavy "rag"; the flesh was coarse, but tender and juicy, and with very pleasant acidity.

No. 80. *Riverside Seedling Blood*, from Riverside. Grown by J. E. Cutter on a tree budded on sour stock. It was received March 27th. The sample was smaller than the other (Riverside) Bloods, but about the same in color; the skin and "rag" were thick, peeling off easily; the flesh was coarse in texture, tender and juicy; the color of the juice was darker, if anything, than that of the Ruby (No. 78), both juices being very tart to the taste.

No. 67. *Jaffa*, from Porterville, Tulare County. The sample was grown by Geo. Frost, and received on March 3d in very good condition. The skin was rough and brilliantly colored; the samples were both rounded and elongated in shape, and rather larger than the ordinary Seedling—in fact, nearly as large as a Navel; the flesh was tender and juicy.

No. 70. *Star*, from Porterville, Tulare County. The sample was grown by Geo. Frost, and received on March 3d. Its color was high, its rind and "rag" very thick, and its pulp tender and juicy.

No. 82. *Parson Brown*, from Riverside. The sample was grown by J. E. Cutter, and received on March 27th. It was round in shape, with flattened base and apex; its skin thick and slightly ribbed, quite rough, and red colored, and separated very easily from the flesh; the flesh was tender, juicy, and pleasant to the taste.

No. 83. *Du Roi* (true ribbed), from Riverside. The sample was grown by J. E. Cutter, and received for analysis on March 27th. The fruit was rather elongated in shape, the base and apex being flattened; the skin was ribbed and rough, with thick "rag"; the flesh was quite tender, but "watery" to the taste.

No. 84. *Pineapple*, from Riverside. The sample was grown by J. E. Cutter, and received on March 27th. It was brilliantly colored, round in shape, somewhat ribbed and rough-skinned, the base and apex flattened; the skin and "rag" were thick and easily separated from the flesh; the flesh was tender and had a distinct flavor of pineapple.

No. 92. *Tardive* (*Valentia Late*), from Riverside. The samples were raised on sweet stock by T. P. Edwards, and received for analysis on June 8th. They were more rounded in shape than those examined in former crops, but still they were slightly elongated; the rind was quite thick, but separated easily from the flesh; the flesh was very tender and juicy; the juice was sweet, and the acid pleasant.

Discussion of Analytical Results.

The accompanying table gives the results of the analyses of citrus fruits of crop of 1892–93, just described above, and *averages* of analyses of those fruits of the crops of 1890–91 and 1891–92, which were reported and discussed in Agricultural Reports for the years 1890 and 1891–92. The question of the distribution of nitrogenous materials in these fruits has now been more fully worked out than formerly, thus giving us some more definite information than is set forth in European reports (referred to in our paper in Agricultural Report for the year 1890, page 112) upon the contents of nitrogen in the *flesh* and *rind* of citrus fruits.

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As indicated above, in referrring to the late reports of this department, we shall only discuss in a brief way some of the main features shown in the table.

Proportion of Rind to Flesh.—The additional data for the year 1893, in the tables relating to the proportion of skin to flesh, in no way change the previous conclusions, but only verify them. Thus the consumer finds that the largest orange—the Navel—has but little, if any, advantage, because of its size, over the smaller Seedling, Mediterranean Sweet, St. Michael, Bloods, and Tardive oranges. The average percentage ratios, as given in the following table, show that on an average the Navel consists of about 72 per cent of flesh and 28 per cent of rind; the average Seedling 75 per cent of flesh and 25 per cent of rind; the average Mediterranean Sweet, Malta and Ruby Bloods about 70 per cent of flesh, with 30 per cent of rind; while the two varieties, St. Michael and Tardive, yield 80 per cent of flesh and only *20 per cent* of rind, or from 8 to 10 per cent less waste material than the other largely grown varieties of oranges just named.

The Riverside Navels of the last crop (Nos. 75 and 91), with 75 per cent of flesh, show a very material advantage in amount of flesh over that from Porterville (No. 68), which has but 64 per cent. They rate on the whole higher in flesh than the majority of the earlier crop Navels, with the exception of No. 4 (1891), from Riverside, and No. 8 (1891), from Pomona. Among the St. Michaels, the Riverside sample, No. 76 (1893), leads for that year with 85 per cent of flesh and 15 per cent of rind; still these figures are outdone by the results of the previous year (1891), in which No. 15, from Pomona, has 85.6 per cent of flesh and 14.4 per cent of rind. The Porterville St. Michael, No. 71, with 80.5 per cent of flesh, is quite within the average. The Bloods from both Riverside and Porterville, Nos. 79, 73, 78, and 69, run very much alike in flesh percentages, varying but little from the average given above. The Parson Brown orange, No. 82, and the Riverside "Seedling" Blood, No. 80, with about 63 per cent of flesh, are but little poorer than either the Star, No. 70, or the Pineapple orange, No. 84, which have about 66 per cent of flesh and 34 per cent of rind. The Du Roi, from Riverside, No. 83, and the Jaffa, No. 67, from Porterville, each have about 70 per cent of flesh, thus rating like the Bloods.

An analysis (reported in Bulletin No. 17, Florida Experiment Station) of the Jaffa orange gives for the peel, or rind, 23.49 per cent of flesh; for the seeds, 0.76 per cent, and for the pulp and juice (flesh), 76.74 per cent; the latter figure being nearly 7 per cent higher than that yielded by Jaffa, No. 67, from Porterville.

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Average Percentage Ratios.

Variety.	No. of Samples.	Proportion of Rind to Flesh.		Proportion of Pulp to Juice in Flesh.	
		Rind.	Flesh.	Pulp.	Juice.
NAVELS.					
Crop of 1885	4	29.0	71.0	32.0	68.0
Crop of 1891	5	28.4	71.6	39.0	61.0
Crop of 1892	4	28.2	71.8	41.0	59.0
Crop of 1893	3	28.1	71.9	40.5	59.5
Average	**16**	**28.4**	**71.5**	**38.1**	**61.9**
SEEDLINGS.					
Crops of 1880–85	7	26.0	74.0	26.0	74.0
Crop of 1891	None.				
Crop of 1892	6	24.0	76.0	37.0	63.0
Average	**13**	**25.0**	**75.0**	**32.5**	**67.5**
MEDITERRANEAN SWEET.					
Crops of 1885–86	3	30.0	70.0	25.0	75.0
Crop of 1891	3	27.0	73.0	33.0	67.0
Crop of 1892	2	30.0	70.0	41.0	59.0
Crop of 1893	2	29.2	70.8	36.8	63.2
Average	**10**	**29.1**	**70.9**	**33.4**	**66.6**
ST. MICHAELS.					
Crops of 1885–86	5	19.0	81.0	23.0	78.0
Crop of 1891	5	19.0	81.0	31.0	69.0
Crop of 1892	2	22.0	78.0	40.0	60.0
Crop of 1893	3	18.2	81.8	37.2	62.8
Average	**15**	**19.5**	**80.5**	**32.8**	**67.2**
MALTA BLOOD.					
Crop of 1885	1	27.0	73.0	30.0	70.0
Crop of 1891	3	31.0	69.0	36.0	64.0
Crop of 1892	None.				
Crop of 1893	2	33.0	67.0	37.5	62.5
Average	**6**	**30.3**	**69.7**	**34.5**	**65.5**
RUBY BLOOD.					
Crop of 1892	2	33.2	66.8	36.7	63.3
Average 1892-93	**3**	**31.8**	**68.2**	**35.7**	**64.3**
KING.					
Crop of 1887	2	23.2	76.8	23.0	77.0
Crop of 1892	1	49.3	50.7	50.0	50.0
Average	**3**	**31.9**	**68.1**	**32.0**	**68.0**
TARDIVE. (Valentia Late.)					
Average 1892-93	**2**	**20.0**	**80.0**	**33.4**	**66.6**

Juiciness, or Proportion of Juice to Flesh.—A comparison of the figures, especially the average, in the large table, shows that, of the named varieties examined, the Navel is the driest, and while the St. Michael and Tardive have the largest proportions of juice, they are closely followed in that respect by the Mediterranean Sweet, Seedlings, and Malta Blood. It is interesting to note that the King orange, one so much admired in Southern California, seems to promise to equal, if not exceed, the St. Michael in juiciness. These facts will be better understood by reference to the table above, which gives the percentage ratios.

Sugar Contents of the Juice.—In the main the highest sugars are seen in that fruit raised in 1892, but the differences are only slight in any variety, so that the averages for this important ingredient of oranges

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are hardly changed by the later work accomplished. Our examination of those varieties of oranges not largely grown in this State, as represented by the Jaffa, Star, Parson Brown, Du Roi, and Pineapple, does not seem to show that *they* give promise of developing higher saccharine properties than the others; however, we have seen that the King and Mandarin oranges from southern counties do give such promise.

Average Percentages of Sugar and Acid.

Variety.	No. of Samples.	Sugar.	Acid.
NAVELS.			
Crop of 1885	3	9.89	1.04
Crop of 1891	6	9.92	1.02
Crop of 1892	4	11.57	1.02
Crop of 1893	3	11.47	.79
Average	**16**	**10.46**	**.97**
SEEDLINGS.			
Crop of 1885	5	9.50	.94
Crop of 1891	1	10.09	1.68
Crop of 1892	6	12.63	1.29
Average	**12**	**11.11**	**1.17**
MEDITERRANEAN SWEETS.			
Crop of 1885	1	10.00	1.09
Crop of 1891	3	9.70	1.38
Crop of 1892	2	9.70	1.29
Crop of 1893	2	8.80	1.27
Average	**8**	**9.55**	**1.75**
ST. MICHAELS.			
Crop of 1885	3	9.70	1.14
Crop of 1891	5	8.71	1.15
Crop of 1892	2	10.10	1.21
Crop of 1893	3	9.99	1.14
Average	**13**	**9.65**	**1.16**
MALTA BLOOD.			
Crop of 1885	1		1.43
Crop of 1889	3	10.30	1.61
Crop of 1893	2	9.88	1.19
Average	**6**	**10.10**	**1.41**
RUBY BLOOD.			
Crop of 1893	2	10.12	1.31
Average 1892-93	**3**	**11.08**	**1.51**
KING.			
Crop of 1887	2	13.95	1.32
Crop of 1892	1	11.60	1.84
Average	**3**	**13.17**	**1.49**
TARDIVE (VALENTIA LATE).			
Average 1892-93	**2**	**9.98**	**1.00**

The above table, showing the average percentages of sugar and acid, develops the fact that the several varieties of oranges range in the following order in point of sweetness, or sugar contents: Seedlings, with 11.11 per cent of sugar in juice; Navels, 10.46 per cent; Malta Blood, 10 per cent, and St. Michaels and Mediterranean Sweets, each about 9.60 per cent. Of course, the King and Ruby Blood are not included in the statement, as but comparatively few samples of these varieties have come under our hands. Individual samples, however, form notable exceptions to the above figures, for we find the Seedling, No. 39, from Englewood, Los Angeles County, to have 14.70 per cent sugar (the maximum); the King, No. 45, from Riverside, 14.62 per cent, and the Mandarin, No. 47, from San Gabriel, 13.84 per cent.

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Some of the latest crop of Navels show higher figures than the general average (10.46 per cent sugar), No. 75, picked about March 1, 1893, and No. 91, picked in the latter part of April, 1893, both from Riverside and grown on sour stock, carry, on the average, 12 per cent sugar, which figure is not bettered among the usual named Navels. No. 31, "Thomson's Improved Navel," crop of 1892, gave 13.10 per cent sugar. No. 68, from Porterville, gathered on the 1st of March, had quite the average sugar contents for a Navel. With the exception of the Seedling, No. 74, with 10.16 per cent sugar as against 11.11 per cent for the average seedling, we may pass the Mediterranean Sweets, St. Michaels, and Malta Bloods of the crop of 1893, with the remark that they hold their own in respect to sugar.

By reference to the following table, already published in Bulletin No. 102, the relations between the average *sugar* and the average *acid* contents of some California fruits will easily be seen. For convenience of comparison the acid is expressed in terms of sulphuric acid (SO_3).

Percentages of Sugar and Acid.

No. of Analyses.	Fruits.	Juice.		Flesh.	Whole Fruit.
		Acid, Per Cent.	Sugars, Per Cent.		
80	Oranges	1.28	10.68	7.12	5.40
4	Figs, White Adriatic	.21	19.70		19.20
37	Other figs	.10 to .20	10 to 29.00		8.0 to 19.20
11	Apricots	.68	13.31	11.93	11.10
13	French prunes	.31	23.69	19.70	18.53
3	Plums	.48	17.97	13.25	12.89
2	Peaches	.24	17.00	13.40	12.50
	Grapes	.50	24.00	23.00	20.70

Acid in the Juice.—Here, again, we are obliged to make the observation that the latest results relating to acidity do not admit of any changes being made upon the *averages* presented in the table for acid contents in the juice of oranges. Taking the acid of the average Seedling (1.20 per cent) then, as a starting point, on account of its very agreeable taste, especially as it is combined with the highest sugar, we may rate the average Navel, with its 1.00 per cent, as rather low in acid, but combined with the second highest sugar; and the average Mediterranean and St. Michael, with about 1.20 per cent, as containing an adequate, pleasant acid, but combined with much less sugar. The Malta and Ruby Bloods, with an average of 1.45 per cent of acid, may be considered high in this respect, in combination, too, with a quantity of sugar that nearly reaches that possessed by the average Navel. Like the Bloods, the King orange stands high in acid and sugar.

In as far as this work has progressed with the next named fruits, we may put the Jaffa, No. 67, with 1.15 per cent, the Star, No. 70, with 1.25 per cent, and the Du Roi, No. 83, with 1.19 per cent, as adequate in acid; and the Tardive, with an average of 1.00 per cent, the Pineapple, No. 84, with 0.64 per cent, and the Parson Brown, No. 82, with 0.78 per cent. as low in acid; all, too, in combination with only moderate amounts of sugar. Still very much lower than these varieties, as previously reported.

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stands the Mandarin, No. 47, with only 0.36 per cent acid (the lowest of all), but the sugar of this variety rates among the very highest.

The results obtained for each of the well-known or largely grown varieties for the fruit of crop of 1893, are almost the average for all. The exceptions worthy of notice are the Navels, Nos. 75, 91, and 68, with about 0.80 per cent of acid, Malta Blood, No. 73, with 1.02 per cent, and Ruby Blood, No. 69, with 1.17 per cent of acid. The exceptions to the general averages are yet thus found in the earlier crops, for the Malta Blood, No. 18 (1891), with 2.04 per cent, still leads in acid contents; the Ruby Blood, No. 43 (1892), from Nordhoff, with 1.92 per cent; the Riverside King, No. 46 (1892), with 1.84 per cent, and the Seedling, No. 36 (1892), from Tulare, with 1.71 per cent, being the only ones which run anywhere near it. The next highest acids are found in samples of Mediterranean Sweet, No. 41 (1892), from Porterville, with 1.67 per cent; Seedling, No. 33 (1892), from Smartsville, with 1.64 per cent, and St. Michaels, No. 42 (1892), with 1.55 per cent—figures which indicate that these varieties stand in about the same relation to each other in acid contents as they did the previous year (1891); however, those of the crop of 1892 present, on the whole, somewhat the widest range in this respect.

Nutritive Values—Nitrogen Contents.—Passing the discussion of the relative importance that the flesh-forming ingredients (albuminoids) hold in these and among other fruits, for the reason that this matter has heretofore received at our hands much attention and space, we can turn with profit to the question of the distribution of nitrogenous matters in the parts—flesh and rind—of some of our oranges. Basing our calculations upon the whole fruit, we see, in the large table, that, contrary to our earlier conclusions (Bulletin No. 93), the nitrogen in the rind, representing the waste as far as food value is concerned, seems to amount to more than it was there credited. For the rind of the largely grown varieties of oranges contains from one third to one half the total nitrogen, excepting in one instance, St. Michaels (No. 71), where we find it to be as low as one fifth the total. In the rind, too, we notice much more variable results in nitrogen contents than for this ingredient of the flesh, even for the same varieties: witness the Navels, Mediterranean Sweets, and St. Michaels of the crop of 1893.

The *total nitrogen*, then, remaining nearly constant for all the largely grown varieties, averaging about 0.18 per cent, we find the flesh, with an average of 0.12 per cent of nitrogen, holds about *two thirds* of the nitrogen; this represents the available part.

From Bulletin No. 101, page 7, it appears that the waste nitrogenous matter, *i. e.*, that part contained in the shells of the prunes and apricots grown here (like that of the rind of the orange), shows the greatest variation of results: the flesh of prunes and apricots contains a pretty uniform amount of nitrogen.

Under the heading "whole fruit" in the large table is given the percentages of albuminoids contained in the flesh of fresh fruit, or that part available for food; also, for the sake of those interested, the nitrogen contained in the fresh flesh and fresh rind is tabulated under the headings "flesh" and "rind."

To save cross-reference we put here in tabular form the average per-

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centages of albuminoids contained in different fruits examined at this Station and already reported in Bulletin No. 101.

Average Percentages of Albuminoids.

Fruits.	Number of Analyses.	In Whole Fruit—Total.	Calculated upon Whole Fresh Fruit.	
			In the Fresh Flesh, or Edible Portion.	In Fresh Pits, or Rinds.
Oranges.				
California	35	1.140	.760	.380
European (Sicilian)		1.780		
Apricots.				
California	11	1.250	1.088	.162
European		.490		
Prunes.				
California	20	1.012	.837	.175
European		.780		
Plums.				
California	3	1.130	1.000	.130
European		.400		
Apples and Pears.				
European		.375		
Figs.				
California	28	1.522	(1.522)	
European (Smyrna)		1.420		
Nectarines		.731	.625	.106

So far, then, the fig rates *first* in flesh-forming ingredients, with little choice between the apricots and plums for *second;* and for third place the prunes and oranges run nearly even.

LEMONS.

Description of Lemons Received (Season of 1892-93).

(For description of lemons received from the crop of 1891, see Agricultural Report for 1890, page 109; for those of crop of 1892, see same report for years 1891–92, pages 102 and 103.)

No. 90. *Eureka*, from Ontario, San Bernardino County. The samples were grown by J. W. Freeman, and are from the exhibit at the State Fair at Colton. They were picked in November, 1892, and received for analysis March 27, 1893. Their skin was of bright yellow color, and of medium thickness; the base fleshy, and apex sharply pointed. They had a tender flesh, and were without seeds.

No. 88. *Lisbon*, from Ontario, San Bernardino County. The sample was taken from the State Fair exhibit at Colton, and was grown by J. W. Freeman. They were picked in November, 1892, and received here on March 27, 1893. The fruit had a clean, smooth, and bright yellow skin, with slightly flattened base and pointed apex; the skin was slightly ribbed. The flesh was tender, and had very few seeds.

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No. 89. *Genoa*, from Ontario, San Bernardino County. The sample was taken from the State Fair at Colton; grown by J. W. Freeman. They were gathered in November, 1892, and received here on March 27, 1893. The skin was clean and yellow colored; the "rag" thickish; the base fleshy, and the apex pointed. The flesh was tender, and had no seeds.

No. 85. *Royal Messina*, from Nordhoff, Ventura County; grown by J. B. Wickoff. This orange was awarded a special first premium at the State Fair at Colton. The samples were raised on sour orange stock; they were gathered in November, 1892, and received here for analysis on March 27, 1893. The fruit was quite large, slightly ribbed, with apex and base medium fleshy; the skin was smooth, and bright yellow in color, and with a thin "rag." The flesh was seedless and rather tough; the juice intensely acid. Mr. J. E. Cutter states that "this fruit is from young trees, which he describes as the handsomest lemon trees he has seen, strong of growth, and nearly thornless."

No. 86. *Villa Franca*, from South Riverside. Grown by Dr. R. D. Barber. The samples were taken from the exhibit at the State Fair at Colton. They were raised on sour orange stock, picked in November, 1892, and received here for analysis March 27, 1893. The fruit was of a deep bright yellow color, slightly ribbed, the base and apex not fleshy; the pulp was tough; the seeds few and undeveloped. The juice was not nearly so acid as that of Royal Messina (No. 85), but similar to that of Villa Franca (No. 87) from Ontario.

No. 87. *Villa Franca*, from Ontario, San Bernardino County. Grown by J. W. Freeman. The sample is from the lot of "cured lemons" that was awarded the first premium at the State Fair at Colton. They were picked on January 15, 1893, and received here for examination March 27, 1893. These samples of lemons were the brightest, cleanest, and smoothest skinned of any yet examined from the crops of 1891, 1892, and 1893. The apex and base were both very fleshy; the pulp very tender, and seeds few but well developed.

No. 64. "*Marysville Seedling.*" Grown by A. J. Binney. The samples were picked on December 5, 1892, and cured by C. H. Shinn. They were analyzed on March 2, 1893; they were at that time somewhat shriveled and soft.

No. 65. "*Marysville Seedling.*" Grown by Mr. Dougal. The samples were picked December 5, 1892, and cured by C. H. Shinn. They were received for analysis on March 2, 1893, in a fair, rather soft condition.

No. 66. "*Marysville Seedling.*" Grown by Mrs. Karr. The samples were picked on December 5, 1892, and cured by C. H. Shinn. They were received for analysis on March 2, 1893, in good condition, but not very firm.

Discussion of Analytical Results.

Except for the reports upon some of the new varieties in our hands, the results found below for the crop of 1893 do not present any real differences in percentages of rind, pulp, and acid from those reported for the crops of 1891 and 1892. (See Agricultural Report for years 1891–92, page 112.)

The Rind.—On the whole the varieties examined (nine samples) for the crop of 1893 show the most constant returns in rind contents, averaging but 24.8 per cent; those of the crops of 1891 and 1892 show for the

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average, respectively, 33.7 and 31.6 per cent of rind. The range for the latest crop was between 19.1 per cent rind, found in Villa Franca, No. 86, from Riverside, and 29.6 per cent, in Lisbon, No. 83, from Ontario: while for the 1892 fruit we have noted differences which show that from one fifth to one half the whole fruit was skin; likewise, the 1891 fruit varied in this respect from one quarter to two fifths of the whole fruit for the rind. The minimum of 19.1 and 19.3 per cent of rind is found, respectively, in the Villa Franca, No. 86, and the Lisbon, No. 52 (Tulare, of 1892), among the named varieties; the maximum, as yet found, 49.8 per cent, still remains with the Seedless, No. 58, from Azusa.

The Pressed Pulp.—The results as given in the averages for all the crops systematically studied are strikingly alike, all being upwards of 25 per cent. The fruit of 1892 shows the widest variation among the named varieties; viz., from 20 to 35 per cent of pulp. After removing the juice we have then for the waste part of our lemons 55 per cent, made up of the rind, 29.2 per cent, and of dry pulp, 25.5 per cent.

The Acid.—The fruit of the crop of 1893 shows the highest acid on the average, and, too, the maximum acid percentage for a single lemon thus far obtained among all here examined, viz., 8.40 per cent in the juice of the Royal Messina, No. 85, from Nordhoff. This figure is very nearly approached, however, by that given for the Eureka, No. 48, from Nordhoff (crop of 1892), namely, 8.33 per cent. Other high acid percentages have been reported, the Eureka, No. 49, from Englewood, yielded 8.14, and Seedling, No. 64, from Marysville, gave 8.12 per cent acid. The minimum acid is found in Seedless, No. 58, from Azusa.

ANALYSES OF CITRUS FRUITS (CROP OF 1893-4) FROM THE SOUTHERN CALIFORNIA MIDWINTER FAIR ASSOCIATION EXHIBIT, SAN FRANCISCO, CAL.

The fruits here reported upon—twelve samples of oranges, nine samples of lemons, and one sample of pomelo, or grape-fruit—were sent for examination by Frank Wiggins, Esq., Superintendent of Southern California Midwinter Fair Association, Midwinter Fair, San Francisco, Cal.

ORANGES.

No. 102. *Navel*, from Duarte, Los Angeles. Grown by A. C. Thomson, and named Washington Navel by sender. The grower calls it "Improved Navel." The sample was received March 12, 1894, in but fair condition, as it was rather soft. Its rind was thick and "corky"; flesh was "mushy," but quite juicy and tart to the taste.

No. 114. *Navel*, from same place and grower as sample No. 102, but picked about June 1, 1894; not exhibited. Fruit was in good condition when received (June 14, 1894), and varied in size and shape, some being large, others only medium in size; some well rounded, others markedly elongated. The rind was quite thick, brittle, and easily separated from flesh. Flesh rather coarse-textured, but very sweet. Mr. Thomson calls this lot his "Improved Navel." Under No. 31, crop of 1892, another analysis is given of this "Improved Navel."

No. 110. *Navel*, from Pasadena. Grown by L. S. Porter, and received here on March 27, 1894. The samples were large but thin skinned, of

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coarse texture, and rather tough flesh; juice very acid for a Navel orange.

No. 100. *Mediterranean Sweet*, from Duarte. Grown by John Scott, and received here on March 12, 1894. A round-shaped, deep yellow-colored fruit, with a brittle but not very thick rind, which was easily removed from the flesh. Its flesh was somewhat coarse, but tender and juicy. Seeds well developed.

No. 101. *St. Michael*, from Duarte. Grown by John Scott, and received here on March 12, 1894. Fruit was round in shape, very large, and of bright lemon-yellow color. Skin rather thin, and separated easily from the flesh. Seeds well developed.

No. 109. *St. Michael*, from Porterville, Tulare County. Grown by G. F. Frost, and received here on March 12, 1894. A good typical sample of the variety, with very firm flesh and well-developed seeds.

No. 103. *Malta Blood*, from Duarte. Grown by M. D. Johnson, and received here on March 12, 1894. Color yellow to red-yellow, with reddish spots; shape tends to be elongated; skin rather thick; flesh marked with characteristic streaks.

No. 107. *Malta Blood*, from Porterville. Grown by G. F. Frost, and received March 12, 1894. Some of the fruit was round in shape, others elongated, and all had thick skins; no seeds.

No. 108. *Ruby Blood*, from Porterville. Grown by G. F. Frost, and received March 12, 1894. Fruit and flesh colored deep red, juice wine red; skin and "rag" quite thick; flesh loose-textured; seeds round in shape and flattened.

No. 99. *Tardive* (*Valentia Late*), from Duarte. Grown by John Scott. Fruit globular shaped, quite unlike some former samples (No. 92), which were elongated. This sample had a brilliant yellow-colored, thin skin (quite as thin as that of a typical paper-rind St. Michael), which easily separated from the flesh. Its seeds were well developed, and the flesh was tender, delicate, and melting.

No. 106. *Jaffa*, from Porterville. Grown by G. F. Frost, and received March 12, 1894. A bright-colored, clean fruit, with medium thick "rag" and skin; seeds small but perfect; juice sweet and quite tart.

No. 105. *King*, from Riverside. Grown by J. E. Cutter, and received for examination on March 12, 1894. Fruit larger than some of the earlier samples examined here (Nos. 44 and 45), but characteristic as to shape and rough appearance.

LEMONS.

No. 97. *Eureka*, from Ontario, San Bernardino County. Grown by J. W. Freeman. This fruit was firm, and its skin and "rag" thick and solid; its flesh was tender, fairly juicy, and contained no seeds.

No. 112. *Eureka*, from San Diego. Grown by F. O. Wadsworth. This fruit was slightly above the usual size, and had a thick, heavy skin and "rag"; firm flesh and few long and pointed but poorly developed seeds.

No. 96. *Lisbon*, from Ontario. Grown by J. W. Freeman, and received March 12, 1894. The fruit was variable in shape; quite firm; skin and "rag" thick; flesh tender and juicy; seeds few and undeveloped.

No. 98. *Genoa*, from Ontario. Grown by J. W. Freeman, and received March 12, 1894. A firm fruit, with thick skin and "rag," and tender flesh.

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No. 95. *Villa Franca*, from Ontario. Grown by J. W. Freeman, and received March 12, 1894. This fruit was firm, strongly apiculate, bright colored, and tending to be ribbed. Its skin and "rag" were thick, and it had a flesh of fine texture; was fairly juicy, and had but few seeds.

No. 113. *Villa Franca*, from San Diego. Grown by S. M. Marshall, and received March 27, 1894. A fairly sized sample, with short, oval, pointed apex and base; heavy, thick skin and "rag," and few well-developed seeds.

No. 94. *Villa Franca*, from San Diego. Grown by the San Diego Land and Town Company, and received for analysis on March 12, 1894. This fruit was very large for the kind, rounded in shape, and had a flat base and rather blunt apex. Its skin and "rag" were rather thick; the flesh was coarse-textured and hollow in center; seeds few in number and abortive.

No. 93. *Villa Franca*, from Porterville. Grown by R. Lindner, and received March 12, 1894. Sample was rather small and soft, and showed upon its thin skin some appearance of coast scale. Its stalk end was somewhat pointed, apex was apiculated. The flesh was tender and contained some fairly developed seeds.

No. 111. *Bonnie Brae*, from San Diego. Grown by J. S. Harvey, and received here on March 27, 1894. A bright-colored, egg-shaped fruit, with a very thin skin, which parted easily from the flesh. The flesh segments showed plainly through the skin, but the fruit could not be called ribbed. The flesh was "mushy" and without any seeds.

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Partial Analyses of Oranges and Lemons (Crop of 1894) from the Midwinter Fair, Southern California Citrus Exhibit.

Number	Variety.	Place of Production.	Grower.	Date of Reception and Analysis.	Physical Analysis.					Analysis of Juice.			
					Average Weight, in Grams*	Rind	Pulp Pressed	Seeds	Juice, in ccm.†	Solid Contents by Spindle	Total Sugars (Inversion)	Cane Sugar (polariscope)	Acid, Citric
	Oranges.												
102	Washington Navel	Duarte	A. C. Thomson	March 12, 1894	184	30.3	34.8		69	13.01	11.00		1.40
114	Washington Navel	Duarte	A. C. Thomson	June 14, 1894	260	27.3	36.3		92	15.20	12.55		0.71
110	Washington Navel	Pasadena	L. S. Porter	March 12, 1894	307	18.6	41.0		100	13.80	11.50		1.68
100	Mediterranean Sweet	Duarte	John Scott	March 12, 1894	210	22.5	30.9		95	11.40	9.65		1.28
101	St. Michaels	Duarte	John Scott	March 12, 1894	167	13.5	28.1	2.1	75	12.40	10.30		1.22
109	St. Michaels	Porterville	G. F. Frost	March 12, 1894	116	19.3	30.0	1.0	51	13.55	10.82		1.30
103	Malta Blood	Duarte	M. D. Johnson	March 12, 1894	170	33.3	30.0		50	12.80	9.80		1.50
107	Malta Blood	Porterville	G. F. Frost	March 12, 1894	150	30.0	26.0		62	13.10	10.60		1.40
108	Ruby Blood	Porterville	G. F. Frost	March 12, 1894	140	37.0	27.0	1.2	43	13.90	10.80		1.50
99	Tardive (Valentia Late)	Duarte	John Scott	March 12, 1894	150	15.2	29.8	1.1	70	13.50	11.00		1.27
106	Jaffa	Porterville	G. F. Frost	March 12, 1894	147	27.2	29.8	0.7	58	13.20	10.80		1.61
105	King	Riverside	J. E. Cutter	March 12, 1894	136	45.7	19.2	2.7	36	14.70	11.70		2.20
	Lemons.												
97	Eureka	Ontario	J. W. Freeman	March 12, 1894	110	44.1	13.5		42	10.00	1.80		6.96
112	Eureka	San Diego	F. O. Wadsworth	March 27, 1894	118	38.8	30.0		37	12.40	3.46		7.77
96	Lisbon	Ontario	J. W. Freeman	March 12, 1894	108	33.3	24.2		40	10.20	2.16		7.00
98	Genoa	Ontario	J. W. Freeman	March 12, 1894	112	44.1	23.5		36	10.70	2.20		7.68
95	Villa Franca	Ontario	J. W. Freeman	March 12, 1894	110	40.6	20.3		39	10.50	1.87		8.01
113	Villa Franca	San Diego	S. M. Marshall	March 27, 1894	103	38.6	26.6	2.5	33	11.40	2.80		8.05
94	Villa Franca	San Diego	San Diego Land and Town Company	March 12, 1894	150	35.5	30.0		40	10.70	2.30		7.91
93	Villa Franca	Porterville	R. Lindner	March 12, 1894	94	28.0	28.0		50	11.80	2.66		7.84
111	Bonnie Brae	San Diego	J. S. Harvey	March 12, 1894	122.5	12.7	37.7		56	8.50	2.20		5.74
104	*Pomelo, or "Grape-Fruit"*	Duarte	F. M. Douglass	March 12, 1894	357	23.5	37.0	3.7	95	13.20	9.50	5.00	2.70

*Thirty grams are equivalent to one ounce. †Thirty cubic centimeters are equivalent to one fluid ounce.

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A few words of comparison upon these results, and those of earlier crop fruits, from the same and different localities, is necessary in order to bring out more definitely what is indicated by the above figures.

Comparison of Average Weights.—Oranges: From a comparison of Table A (analyses of California orange crops of 1891, 1892, and 1893), p. 242 of this report, with the figures given just above, it seems that most of the varieties of oranges from the exhibit at the Midwinter Fair weigh *less* than the earlier fruits; for we note that of the eight varieties examined, the Navels, Malta and Ruby Bloods, Tardive, and Jaffa oranges range *less* in weight, while Mediterranean Sweet, St. Michael, and King varieties are nearly the average in this respect. Jaffa, No. 106, from Porterville, and Tardive, No. 99, from Duarte, vary the most of all. The effect of season has doubtless much to do with some of these variations. *Lemons:* Most of the varieties of lemons from the exhibit do not show much difference in weight from those examined in previous years. (See also Table B, analyses of California lemons, crops of 1891, 1892, and 1893, p. 249 of this report.) Villa Franca, No. 94, from San Diego, from the exhibit, was the only remarkably large sample, as compared with the other Villa Francas, and the majority of all the lemons examined, standing as it does in weight about as one and one half to one, or 150 grams (5 ozs.) to 108 grams (3 ozs.) for the average weight. We have, however, found some earlier samples of unnamed varieties of lemons equal to it in weight, and even heavier.

Comparison of Rind Percentages.—Oranges: The rind percentage of the Navels from the exhibit is about the average, except that of No. 114 (18.6 per cent), which, while 10 per cent below the average, is still higher than that we have reported for a sample, No. 4, from Riverside, with 17.5 per cent. The averages referred to are found on p. 244 of this report. The Mediterranean Sweet and Tardive (Valencia Late) from the exhibit yield lower rind percentages than that given for the averages, respectively 7 and 5 per cent less. The Jaffa and Malta Blood are nearly the average, while the Ruby Blood is some 5 per cent higher than the average for that variety in rind. The King orange, with nearly 46 per cent of rind, still does not come up to that of the sample from the same locality, of the crop of 1892, with its 49 per cent rind. *Lemons:* When we compare the figures for rind contents of the exhibited fruits with those upon p. 249 of this report, it is evident immediately that the exhibited lemons run notably higher in rind than the earlier crop lemons, even where they come from the same locality and the same grower. Bonnie Brae, No. 111, from Duarte, presents a very low figure, 12.7 per cent, for skin, which we are not accustomed to see in lemons, although an earlier analysis of Bonnie Brae from San Diego shows 15 per cent rind. The objection to this variety of lemon is, as has been said before in the Agricultural Report for 1882, that its acid is over 2 per cent less than the average.

Sugar Contents of the Juice.—Oranges and Lemons: The amount of sugar in the juice of the exhibited fruits compares, on the whole, favorably with the figures for that (averages) on page 245. For the Navels (leaving out No. 114, on account of its late gathering), we find a difference of from a half to one per cent more sugar in the last fruit examined; the juices, too, of the St. Michaels, Malta Blood, and Tardive are a little sweeter (by analysis) than the earlier fruits. The King and Malta Blood, however, do not reach in saccharine contents within one per cent

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of the averages for these varieties. The Tardive, No. 99, contains about one per cent more sugar than the 1892–93 fruits of the same name. The lemons from the exhibit show some variation in sugars from those previously examined, though not enough to make it profitable to extend the comparison here.

Acid in the Juice.—Oranges: The Navels (excepting No. 114, picked in June, 1894), Jaffa, Tardive, and King oranges from the exhibit yield nearly half as much again acid as do the fruits averaged and tabulated on page 245 of this report. Those varieties showing similarity with the averages for acid contents are the Mediterranean Sweet, St. Michaels, and Malta and Ruby Bloods. The "Improved Navel" from Duarte, represented by Nos. 31 (Agr. Rept. for 1891–92, p. 100, and table on p. 104), 102, and 114, is a very remarkable orange, in that it is capable of being gathered from December to the following June, and at the same time yield such desirable combinations of sugars and acids. No. 114, picked in June, contains 12.55 per cent sugar—2 per cent above the average for Navels—with 0.71 per cent acid, the least figure yet returned for this ingredient—0.25 per cent less than the average. No. 31, gathered in March, has an even higher saccharine content, 13.10 per cent, together with 1.20 per cent acid, and indicates a better balanced fruit. No. 102, picked for the Midwinter Fair exhibit, and received here in March, yields a high sugar, 11 per cent, as well as a high acid, 1.40 per cent. These facts when considered with those given above, in the description, relating to size, appearance, medium rind, palatableness, etc., recommend this fruit to the careful attention of growers and consumers. *Lemons:* Aside from the Bonnie Brae, No. 111, it is safe to say that the exhibited lemons compare favorably with the earlier ones in regard to their acidity, ranging very close to the average, *i. e.*, upwards of 7.5 per cent; still none of them reach the figure of 8.40 per cent acid, found in Royal Messina, No. 85, from Nordhoff.

POMELO, OR "GRAPE-FRUIT."

No. 104. Sample grown by F. M. Douglass, of Duarte, and received on March 12, 1894. The fruit was nearly round in shape; skin varied from light to deep lemon-yellow in color; "rag" abundant. Its flesh was lemon colored, rather "mushy," but juicy; flavor of juice, "bitter-sweet." Seeds were numerous, large, flat, and rugose.

Only one other sample of this fruit, a pear-shaped one, from Oroville, has been previously analyzed and reported upon at this Station (Agr. Report for 1887, p. 76). We give the analysis here again, with that of the Midwinter Fair sample described just above.

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Analyses of Pomelo, or "Grape-Fruit."

	Pear-Shaped Pomelo.	Round-Shaped Pomelo.
Date of receipt and analysis	January, 1886	March 12, 1894
Physical Analysis—		
Average weight, in grams	344.00	357.00
Rind, per cent	33.00	23.50
Pulp, pressed, per cent	15.00	37.00
Seeds, per cent.	5.00	3.70
Juice, in ccm.	143.00	95.00
Analysis of Juice—		
Solid contents by spindle, per cent	9.49	13.20
Total sugars, per cent		9.50
Cane sugar, per cent		5.00
Acid, citric, per cent	1.92	2.70

(These specimens show too high an acid percentage to make them agreeable to most tastes. Pomelo varieties are now becoming very popular at the East, and Florida growers are said to find the production quite profitable. Selected seedlings are being propagated because of superiority in thinness of skin and reduction of the acridity and acidity of the juice. Probably California must advance in the same manner in the development of better pomelos, if the fruit is to become popular for local use or for Eastern shipment. E. J. W.)

Note.—Very lately we have received from Japan an interesting report by Prof. M. Fesca, of the Imperial Geological Institute, in which the Agricultural Experiment Station of *Komaba* furnishes some analyses of Japanese grown oranges. The results are reported upon the whole fruit and we have, in part, rearranged them for comparison with figures which this Station gives for our oranges.

Japanese Oranges.

Name of Variety.	Unshiu.	Kishiu.
Water, per cent	84.20	85.10
Organic matter, per cent	13.01	11.71
Ash, per cent	2.79	3.19
Totals	100.00	100.00
Nitrogen, whole fruit, per cent	.18	.16
Albuminoids corresponding to nitrogen, per cent	1.12	.68
Percentage Composition of the Ash.		
Potash	44.44	42.63
Soda	10.04	7.83
Lime	21.11	22.57
Magnesia	8.58	6.58
Peroxid of iron (not reported)		
Br. oxid of manganese (not reported)		
Phosphoric acid	10.40	16.00
Sulphuric acid	3.65	3.10
Silica	.70	.66
Chlorine (not reported)		
Totals	98.92	98.57

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EXAMINATION OF CALIFORNIA PRUNES, APRICOTS, PLUMS, AND NECTARINES.

By GEO. E. COLBY.

(*Experiment Station Bulletin No. 101.*)

Note.—For the purposes of this discussion a distinction is made between plums and prunes, as is common in the horticultural literature of this State. By the term "prune" is signified a plum which dries successfully, without removal of the pit, and produces a sweet dried fruit, though in the confusion of our nomenclature, not even this broad classification is faithfully followed. For example, we have the "Hungarian prune" as a local traditional name for Pond's Seedling plum, which has no value as a prune; and we have also Coe's Golden Drop plum, which does answer the requirements for a dried prune, and in that form is marketed as a prune, and sometimes given fancy names by packers. We do not, however, in this publication, attempt to correct the classification, but follow the popular arrangement.

The order of enumeration of fruits in the head line above, and in the tabular statements which follow, is based upon the relative commercial importance of the fruits in this State. An arrangement of the chief table of analyses is also made to bring into juxtaposition the varieties from adjacent regions of the State that effects of local climates and soils upon the same variety may be disclosed if such exist. As this is only the beginning of such investigation, the results in this regard should be looked upon as tentative. Many more analyses are required to demonstrate constant differences of this nature, and we invite the sending of representative samples of named varieties from all parts of the State. It is well to send about ten pounds of each variety, each specimen being wrapped to prevent bruising. Such samples may be sent by express at our expense. Each shipment should be accompanied by a letter, giving name of variety, age of tree, and stock upon which it is budded or grafted, location of orchard, and name of grower; also notes of culture, irrigation, etc. Address such shipments to "Agricultural Experiment Station, University of California, Berkeley, Cal."

This bulletin is a continuation of the work reported in Bulletin 97 of this Station, and in some paragraphs the text is reproduced, only changing figures to include the results of a greater number of analyses. It is perhaps only fair to Mr. Colby to state that the analyses of the fruit grown in 1892 are his personal work, and have been made without assistance. (E. J. Wickson.)

The subjects discussed in this paper are summarily set forth in the following quotation from Bulletin No. 93 of this department:

The purpose of this work is to show comprehensively the proximate and ash composition of the leading varieties of fruit as grown in the principal fruit regions; and, inferentially, the influence exercised upon them by the prominent conditions of soil, climate, fertilizers, etc. The physical data (proportion of pits to flesh, etc.) are of interest from a commercial standpoint, as showing what is being purchased as to available and waste material, etc.

The consumer, though usually considering fruit as a luxury, would derive much valuable knowledge from studying the fruits in their relative values as foods. The nourishing portions, shown especially by the nitrogenous and saccharine contents, vary greatly with the variety and conditions of growth. It is not, then, a matter of indifference to the consumer what fruit he uses, but an important question of domestic economy.

The ash ingredients, together with the nitrogen contents of the standard varieties, are of high interest in connection with vital questions of soil exhaustion and fertilization. The soil ingredients extracted by an ordinary crop are a serious drain upon the supporting soil, and the lines of heaviest draft can only become known by the actual determination of the constituents withdrawn.

Description of Prunes, Apricots, and Plums Received in 1892.

(For a description of these fruits received and analyzed in 1891, see Bulletin No. 97, of this Station.)

PRUNES.

No. 31. *French*, from Auburn, Placer County. The sample was grown by Young Bros., and received in good condition on October 7, 1892. It was large in size and with a very sweet taste; its flesh firm and juicy.

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"The soil is red slate, well drained, with a southern exposure; very little irrigation used."

No. 32. *French*, from Newcastle, Placer County. The sample was grown by E. B. Silva, and received September 23d in a somewhat poor condition, the fruit being a little shriveled and very ripe. It was small in size, its flesh rather juicy and very sweet.

No. 33. *French*, from Yuba City, Sutter County. The sample was grown by R. C. Kells, and received on September 27th in a fair condition, but very ripe. "The soil is a sandy loam, dark gray or light brown in color, with a dark clay subsoil. The ranch is about three quarters of a mile from the west bank of the Feather River, and has good drainage. The trees are eight years old, on peach root."

Nos. 34, 35, and 36. *French*, from Campbell, Santa Clara County. Grown by Campbell Fruit Growers' Union. No. 34 was received on September 1st in only fair condition, the fruit being slightly shriveled; the trees have not been irrigated; its size was very large and taste very sweet, though the flesh was not as firm as No. 35. No. 35 was received in good condition on September 1st; trees have been winter irrigated; fruit full-fleshed, oversized, well rounded, and with a firm and tender flesh, more juicy than No. 34. No. 36 was received on September 21st in fair condition, the fruit being slightly shriveled, very ripe, and not as large as the other two; its flesh, like that of No. 34, was rather coarse in texture, and not as juicy or tender as that of No. 35. F. M. Righter, Vice-President of the Campbell Fruit Growers' Union, writes: "There is a great variety of soil in this valley; it is generally a gravelly loam—a sediment deposited by the Los Gatos Creek—and upon this the prunes were grown. This soil is very porous, trees cannot be injured by water during winter;—have had several feet of water around some of my trees as late as June without injuring them. The soil varies in depth from 10 to 18 feet; in some places the soil to the depth of 4 or 5 feet is very sandy, below that there is more clay."

Nos. 40 and 41. *French*, from Ventura, Ventura County. Grown by J. W. Anderson, and received on September 5th. No. 40 is of the usual size, with firm flesh, rather juicy, and sweet. No. 41 was below the usual size and had large pits. "These prunes are from a mountain-valley orchard two and one half miles from the sea, and at an elevation of 700 feet; mountains 2,000 feet high lie between the valley and the ocean. The largest of the prunes, No. 40, was raised on a sandy soil; the others on heavier soils."

No. 42. *French*, from Pomona, Los Angeles County. The sample was grown by P. M. Doyle, and received on September 6th in good condition. It was of usual size, with hard and juicy fruit, but not very sweet. Mr. John S. Calkins, who procured this sample for the Station. writes: "These prunes are from an orchard seven years old, growing on a sandy loam soil and situated one and one half miles northeast of Pomona, on the Kingsley tract. The trees bore a good crop last year and are very full this year."

No. 44. *French*, from near Pomona, Los Angeles County. The samples were grown by J. W. Lawson, and received in good condition on September 20th. Their flesh was tender and juicy. "The orchard is situated two miles north of the Chino Experiment Station, at an elevation of from 300 to 400 feet above the sea. The soil is a sandy loam. The trees are five years old, and irrigation has been resorted to once a

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month during the dry season. The ground has been fertilized but once, and then only stable manure was used."

No. 37. *Robe de Sergent*, from San José, Santa Clara County. The sample was grown by John Rock, and received in good condition on August 25th. It was fully ripe and more juicy than No. 5 of the crop of 1891. The flesh was also tender and sweeter than the latter.

No. 38. *Fellenberg*, from San José, Santa Clara County. The sample was grown by John Rock, and received in good condition on August 25th. It was fully ripe, with a hard and juicy flesh and only moderately sweet.

No. 39. *Bulgarian*, from San José, Santa Clara County, This was also grown by John Rock, and received on September 30th in rather poor condition, overripe, and shriveled. It was examined for comparison of its sugar contents with that of No. 8, the same variety, of the crop of 1891.

Of samples Nos. 37, 38, 39, Mr. Rock says: "Last season (1891) they were all overbearing and lacked flavor; this year (1892) the crop is light and the fruit better. The land on which the prunes were grown is a sandy alluvial soil, made by deposits from Coyote Creek. These deposits are from 4 to 6 feet deep, under which lies a stratum of 3 to 4 feet of loam, and under this a sandy layer lighter than the surface soil. During the summer the ground water is from 14 to 18 feet below the surface."

PLUMS.

No. 45. *Coe's Golden Drop*, from Auburn, Placer County. Grown by Young Bros., and received in good condition on October 7th. The sample was somewhat larger than that from Marysville (No. 46). The flesh was not as firm nor as juicy as the French prunes.

No. 46. *Coe's Golden Drop*, from Marysville, Yuba County. The sample was grown by Dr. S. Jewett, and received in excellent condition on August 30th. The flesh was firm and juicy.

No. 47. *Yellow Egg*, from Marysville, Yuba County. The sample was grown by Dr. S. Jewett, and received in very good condition on August 30th. The flesh was firm and more juicy than that of the plums just mentioned. Both of the samples from Marysville were from trees six years old growing on a heavy sandy loam soil with clay subsoil.

APRICOTS.

No. 25. *Royal*, from Concord, Contra Costa County. The sample was grown by J. T. Sutton, and received in good condition on August 1st. It was taken from trees three years old and was very large and fully ripe.

No. 26. *Royal*, from Oleander, Fresno County. The sample was grown by J. H. Harding, and received on June 24th, in excellent condition. It was under the usual size, the flesh quite juicy, but not very sweet, and with a peachy flavor. "This year my trees are so heavily loaded that the fruit is very small; the trees have not had any irrigation for two years; age of trees, nine years; have made only medium growth, and have borne very heavily for five years. Soil sandy, slightly tending to white ash, sub-water-level 10 feet below surface."

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No. 27. *Royal*, from Santa Maria, San Luis Obispo County. It was grown by L. E. Blochman, and received on August 10th in good condition, quite ripe, and with high color. It was of the usual size and with a firm and rather juicy flesh.

No. 28. *Royal*, from North Pomona, Los Angeles County. It was grown by Mrs. J. L. Loomis, and received on July 2d, in an excellent condition, fully ripe and quite large and with tender and very juicy flesh. Mr. J. S. Calkins, who obtained the samples for the Station, writes: "Trees seven years old, in gravelly loam soil, irrigated once this year. The location is about three miles south of the foothills of the Sierra Madre Mountains."

No. 29. *Hemskirk*, from Oleander, Fresno County. It was grown by A. Allison, and received on June 25th in good condition; its flesh was firm and juicy. "The trees are nine years old, and heavy, regular bearers. The soil is of the white ash variety, with the water-level 7½ feet below the surface."

No. 30. *Moorpark*, from Oleander, Fresno County. The sample was grown by J. H. Harding, and received in very good condition on June 25th. It was of a light color. "The soil is sandy. The trees are nine years old, and have not been irrigated. The water-level is at 10 feet from the surface."

NECTARINES.

No. 48. "*The New White*," from Yuba City, Sutter County. It was grown by H. P. Stabler, and received on September 1st in excellent condition. It was light-colored and very large in size, very juicy, and pleasantly tart to the taste. The flesh was very delicate.

Results of Analyses.

The table given below shows the results of the analytical work for the seasons 1891 and 1892, that of 1892 covering a greater area of the State than that of 1891, which dealt mostly with Santa Clara Valley fruits. Subdivision A gives the physical and general proximate analyses, and under this head we have added to that of the previous season, the separation of the pit into its component parts—shells and kernels—and reported upon the nitrogen contents of these separate parts. Subdivision B gives the results of the complete analysis of the ash, in which we have considerably extended the work, as compared with that of 1891, to Northern and Southern California fruits.

In the following discussion of the chief points illustrated by the table, we shall use such parts of Bulletin No. 97 as answer for comparison, etc., without further reference to it.

PROPORTIONS OF PITS TO FLESH.

Prunes.—The range in the percentages of pits is from 3.7 in the Hungarian prune, No. 7, to 7.5 in the Robe de Sergent, No. 5; 5.8 per cent representing the general averages for both the French (Bulgarian, No. 39, with 9.2 per cent of pits, by reason of overripeness, is not included in the above statement). The later work, then, verifies our previous conclusion that these fruits contain about seventeen times as much flesh as pits.

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Number	Variety.	Place of Production.	
	PRUNES.		
	NORTHERN CALIFORNIA.		
31	French	Auburn, Placer County	Y
32	French	Newcastle, Placer County	E
33	French	Yuba City, Sutter County	E
	CENTRAL CALIFORNIA.		
1	Prune d'Agen*	Mountain View, Santa Clara County	S
2	Prune d'Agen*	Niles, Alameda County	V
3	French*	San José, Santa Clara County	J
34	French (Unirrigated)	Campbell, Santa Clara County	C
35	French (Winter Irrigated)	Campbell, Santa Clara County	C
36	French (Irrigated in June)	Campbell, Santa Clara County	C
4	Wangenheim*	San José, Santa Clara County	J
5	Robe de Sergent*	San José, Santa Clara County	J
37	Robe de Sergent*	San José, Santa Clara County	J
6	Fellenberg*	San José, Santa Clara County	J
38	Fellenberg	San José, Santa Clara County	J
7	Hungarian*	San José, Santa Clara County	J
8	Bulgarian*	San José, Santa Clara County	J
39	Bulgarian	San José, Santa Clara County	J
9	German*	San José, Santa Clara County	J
10	Datte d'Hongrie	San José, Santa Clara County	J
12	St. Catherine*	San José, Santa Clara County	J
	SOUTHERN CALIFORNIA.		
40	French ("large")	Ventura, Ventura County	J
41	French ("small")	Ventura, Ventura County	J
42	French	Pomona, Los Angeles County	P
43	Same as 42, after keeping three weeks.	Pomona, Los Angeles County	P
44	French	Chino, San Bernardino County	J
49	**Averages—French Prunes (13)**		
50	**Averages—All Prunes (23)**		
	PLUMS.		
45	Coe's Golden Drop	Auburn, Placer County	Y
46	Coe's Golden Drop	Marysville, Yuba County	I
47	Yellow Egg	Marysville, Yuba County	I
51	**Averages of Plums (3)**		
	APRICOTS.		
	CENTRAL CALIFORNIA.		
25	Royal	Concord, Contra Costa County	J
16	Royal*	Niles, Alameda County	J
14	Hemskirk*	Niles, Alameda County	J
15	Blenheim*	Niles, Alameda County	J
17	Peach*	Niles, Alameda County	J
18	Moorpark*	Niles, Alameda County	J
	SOUTHERN CALIFORNIA.		
26	Royal	Oleander, Fresno County	J
27	Royal	Santa Maria, Santa Barbara County	I
28	Royal	Pomona, Los Angeles County	N
29	Hemskirk	Oleander, Fresno County	A
30	Moorpark	Oleander, Fresno County	J
52	**Averages—Apricots (11)**		
	NECTARINE.		
48	"The New White"	Yuba City, Sutter County	E

*Analyses published in Bulletin No. 97. † 30 grams are equivalent to 1 ounce.

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Plums.—In these the range in the percentages of pits, somewhat less than that for prunes, is from 3.4 per cent in Coe's Golden Drop, No. 45, to 6.1 per cent in Yellow Egg, No. 47, the average being 4.8 per cent, leaving nearly twenty times as much flesh as pits. The consumer thus finds that the plums possess a small advantage over the prunes; and the prunes on the whole, as compared with each other, show no appreciable advantage in the proportion of pits to flesh.

Apricots.—For the fully ripe and largely grown varieties from all localities the variation of pit percentages is from 5.3 (Moorpark, No. 30) to 7.1 (Royal, No. 26), a smaller difference than is found in the prunes or plums, viz., 3.8 per cent for prunes and 2.7 for plums, as against 1.8 for apricots. The average pit contents is 6.2 per cent; the flesh then is fifteen times more in amount than pits. Here again there is but a trifling advantage in choice of varieties, so far as the proportion between flesh and pit is concerned.

For equal weights of prunes and apricots (whole fresh fruit), the consumer receives nearly the same amount of flesh or available matter; but the apricots being about 2.7 times larger than the prunes, we have, on the average, 7.5 of apricots as against 20.3 of prunes per pound avoirdupois. This same difference seems to exist between the plums and prunes.

European analyses of these fruits report figures which do not differ materially from those furnished in the above table; the average pit percentages for prunes is 5.4, for apricots 5.3, the weights for whole fruits not being given in the analyses at hand.

The proportion, on the average, of shells to kernels in the pits of the prunes and apricots examined seems to be very constant and nearly the same for both fruits, or about as three to one. The kernels of all of these fruits were full and well developed; the largest pits, however, do not show, for either of these fruits, correspondingly heavy kernels.

PROPORTION OF JUICE TO FLESH.

Prunes and Plums.—The French prune on the average shows the largest proportion of free juice, 4.3 per cent more than the average for all the prunes, namely, 83 per cent, or about *four fifths* of the flesh. No. 7, Hungarian, while the largest of the prunes, has 13 per cent less juice than the average French prune, *i. e.*, 70 as against 83 per cent. The *plums*, although not as large as the Hungarian prune, are, on an average, about 5 per cent higher in juice, a figure which nearly expresses the difference between the French prunes and the plums. *Three fourths* of the flesh of the plum, as an average, is juice, thus showing the prune flesh to be one twentieth more juicy than that of the plum.

Apricots.—The proportion of juice to flesh is nearly the same for all the samples, nine tenths of the flesh being juice. No. 29, Hemskirk, with 93 per cent, being the juciest, and Blenheim, No. 15, with 85 per cent, the driest of the series. The average flesh of the apricots, from this latest showing, is more juicy than that of the prunes, in the ratio of nine to eight.

SUGAR CONTENTS OF THE JUICE, FLESH, AND FRUIT.

The work undertaken for the crops of 1891 and 1892 did not comprehend the determination of the different sugars (dextrose, levulose, cane sugar, etc.), contained in prunes and apricots; the length of time neces-

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sary to complete such an investigation for each sample, required us to limit the work to the determination of the most important point—the total sugars.

Prunes and Plums.—The ripe, juicy, soft-fleshed French prunes from all localities yield the highest percentage of sugar, averaging in the juice 23.69 per cent; the hard-fleshed ripe prunes, represented by Nos. 4, 5, 37, 6, 38, 7, 8, 9, 10, and 12, yield an average of 15.24 per cent of sugar, or 6.24 per cent less than the soft-fleshed; while the average of both soft and hard-fleshed varieties is 20 per cent less than that of the French prunes.

We note, for the later crop of French prunes, a difference of five weeks between the earliest and the latest picking; No. 34 was picked on September 1st, and No. 31 on October 7th, yet these contain nearly identical amounts of sugar in the juice, 25.30 per cent, which when referred to the fresh fruit shows the *earlier* sample to stand 1 per cent lower than the later, on account of its being more juicy.

The maximum sugar percentage, 26.45, in the juice is seen in No. 32, from Newcastle, picked on September 23d; it is 1.45 per cent higher than is found in the earliest and latest French prunes. This sample and the others from the various localities gathered in the *third* and *fourth* week of September, point to that time as yielding the juiciest and sweetest fruits of their kind. No. 42, from Pomona, shows the least sugar in the juice, 17.68 per cent; this sample, after keeping three weeks at a temperature of 60° F., was still only a little shriveled and quite edible, and its juice contained 33.10 per cent sugar, or nearly double that of the original sample.

Referring again to the so-called hard-fleshed varieties, Robe de Sergent, Fellenberg, Bulgarian, etc., we note some differences in the sugar contents in favor of the later crop samples. No. 37, Robe de Sergent, shows 5.38 per cent more than No. 5; No. 38, Fellenberg, 2.5 per cent more than No. 6; No. 39, Bulgarian, nearly 13 per cent more than No. 8; a difference rather greater than we could probably expect if the samples were more nearly alike in maturity. No. 39, as above stated in its description, was far overripe. Some of these results may be explained as due to the evident difference in maturity at the time of the examination for the two crops, and, as Mr. Rock writes in the description above, to the general inferiority of the earlier crop (1891).

The *plums* among themselves show, in the juice, a narrow range in sugar, and average about 18.0 per cent of that substance—some 5.5 per cent less than the French prunes, and about 3.5 more than the hard-fleshed varieties.

Apricots.—The fruit from early localities (picked in June) and that from later points (picked in August) show a remarkably close resemblance to each other in their sugar contents—the Royal, No. 16, with its 15.06 per cent; the Peach, No. 17, with 15.72 per cent, the highest in sugar, showing but about 2 per cent more than the general average, 13.31 per cent, for the juice.

Taking the general averages of sugar in the juice of prunes and of apricots, we find that the prunes run over 6 per cent higher; for the whole fruit, somewhat 4.2 per higher. And as compared with the average French prune, the apricots show for the juice some 10 per cent less of sugar; for the whole fruit, somewhat over 7 per cent less of sugar.

When calculated on the *whole* fruit, the sugars of the apricots and

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plums more nearly resemble each other in amount, the average difference being 1.79 per cent in favor of the plum. From the results at hand, it seems that the nectarine, No. 48, has in the juice nearly 4 per cent more of sugar than the apricot, following in this respect very closely the plums.

European reports of these fruits show that the *juice* of prunes, on the the average, contains 6.15 per cent sugar, and that of apricots 4.69 per cent (one case is reported of a small variety of apricots with 16.5 per cent sugar), these figures being about three times less than those herein presented for these fruits as grown in California. There seems thus to be good cause for the preference they have so quickly attained in the market.

By reference to the small table following, the relations to each other of the average *sugar* and *acid* contents of some California fruits will readily be seen. For convenience of comparison, the acid is expressed in terms of sulphuric acid (SO_3):

Percentages of Sugar and Acid.

No. Analyzed	Fruits.	Juice.		Flesh.	Whole Fruit.
		Acid, Per Cent.	Sugar, Per Cent.		
11	Apricots	.68	13.31	11.93	11.10
23	Prunes	.40	20.00	16.11	15.35
13	French prunes	.31	23.69	19.70	18.53
3	Plums	.48	17.97	13.25	12.89
2	Peaches from Shasta and Butte Counties	.24	17.00	13.40	12.50
1	Nectarines	.62	17.17	15.13	14.11
....	Grapes from various localities	.50	24.00	23.00	20.70
80	Oranges from various localities	1.28	10.68	7.12	5.40
28	Figs	.21	19.70	.....	19.20

ACID IN THE JUICE.

Prunes.—The maximum, nearly 1 per cent, is at once seen in Hungarian, No. 7; the minimum, 0.23 per cent, in the Prune d'Agen, No. 1; the average, 0.40 per cent, being almost twice the minimum.

Plums.—Here again we find a very wide difference, even greater than the prunes show; the maximum being 1 per cent, the minimum 0.20 per cent, and the average 0.48 per cent.

Apricots.—While the acids differ from 0.50 per cent to 0.90 per cent, they do not show as great a diversity as the prunes in this respect, but, on an average, contain, like the nectarine, about 0.20 per cent more of acid.

In all of these fruits it appears that low acids are combined with high sugars. European analyses, which report the acid in terms of malic acid, when corrected for sulphuric acid, as in our report, give for prunes 0.51, for apricots 0.70, and for peaches 0.55 per cent, and these do not differ much, except for peaches, from the results which we give.

NUTRITIVE VALUES—NITROGEN CONTENTS.

"The flesh-forming ingredients of any article of food being of great importance as regards its proper uses (see Bulletin 93 of the department, relating to oranges and lemons), it is of especial interest to compare in

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this respect the prune, plum, and apricot to other fruits, and the different varieties of prunes, plums, and apricots amongst themselves."

The *prunes* of the last crop (1892) have, in general, yielded a higher average albuminoid percentage in the flesh, for we find 0.84 as against 0.76 per cent for crop of 1891. The maximum of the series is seen in Nos. 33 and 44, French prunes, which contain, in the edible portion alone, 1.30 per cent albuminoids, or 0.36 per cent more than the maximum (0.94 per cent) of the crop of 1891. At no great distance we see placed No. 34, with 1.12 per cent of these materials; No. 5, Robe de Sergent, still shows the minimum amount, 0.52 per cent.

The French prunes and *plums* have the same quantity of albuminoids in the flesh, 1.12 per cent. In as far as these flesh-forming ingredients were determined in the hard-fleshed varieties, we do not find such differences as in the French prunes in total amounts between the two crops; Nos. 6 and 38, Fallenberg, having, respectively, 0.139 and 0.140 per cents total, and 0.117 and 0.113 per cents in the fresh flesh; Nos. 5 and 37, Robe de Sergent, yield for totals respectively 0.134 and 0.130 per cents, and for fresh flesh 0.083 and 0.113 per cents.

Among the *apricots*, the flesh shows wide differences in albuminoids, that of Central California fruits yielding the highest figures in most instances, and as compared with prune flesh, much greater variation. The maximum of 1.44 per cent albuminoids, in the flesh, is at once seen in No. 25, Royal, from Contra Costa County, and the minimum of 0.737 per cent in No. 30, Moorpark, from Fresno County, with an average of 1.00 per cent for all.

The following little table shows how the different fruits we have studied may be rated in their albuminoid contents, and distribution of the same in the several parts of the fruit, as well as how they compare with European fruits:

Average Percentages of Albuminoids.

Fruit.	Number of Analyses.	In Whole Fruit, Total.	In the Fresh Flesh, or Edible Portion.	In Fresh Pits, or Rind.
			Calculated upon Whole Fresh Fruit.	
Oranges.				
California	35	1.140	.760	.380
European (Sicilian)		1.780		
Apricots.				
California	11	1.250	1.088	.162
European		.490		
Prunes.				
California	20	1.012	.837	.175
European		.780		
Plums.				
California	3	1.130	1.000	.130
European		.400		
Apples and Pears.				
European		.375		
Figs.				
California	28	1.522	(1.522)	
European (Smyrna)		1.420		
Nectarines		.731	.625	.106

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So far then, the fig rates *first* in flesh-forming ingredients, with little choice between the apricots and plums for *second;* and for *third* place, the prunes and oranges run nearly even. Apparently, the nectarine falls far short of the above fruits in these ingredients, but still ranges considerably higher than apples and pears (from European data only).

With this portion of our work we give below a summary of the food constituents of some of our dried (cured) commercial French prunes, dried apricots, grapes, and figs. The results, while inadequate as a basis for general conclusions as to the relative food values of these fruits, nevertheless indicate plainly that the nutrients, notably the sugar and crude protein (albuminoids), differ very widely; for instance, the sugar in the grape food is about 53, while that in the apricot and apple respectively is 29.5 and 32; and for the French prune 40.5 per cent, and only 5.00 less than is given for the dried fig (White Adriatic). Again, the fig with its 4.50 per cent of crude protein is 1.60 per cent richer than the grape, apricot, and the French prunes; however, these latter fruits are all nearly twice as rich in albuminoids as the apple. The maximum ash is found in the fig, and is on an average about one per cent more than that in the other fruits.

Percentage Composition of Dried Fruits.

Contents—Per Cent.	Dried Edible Portion.		Grapes (Black Malvasia "Grape Food")*	Figs (White Adriatic)	Figs (European, Smyrna)	Apples (European)
	French Prunes.	Apricots				
Water	25.20	32.44	34.83	25.00	20.03	83.00
Ash	1.50	1.38	1.16	2.24	2.45	1.40
Albuminoids (crude protein)	2.80	2.90	2.94	4.50	5.70	1.70
Crude fiber			3.70			8.30
Nitrogen-free extract	29.77	32.18	2.17	10.11	13.82	21.60
Fat			.56			
Sugar	40.53	29.59	52.50	57.60	58.00	32.00
Free acid, calculated as sulphuric (SO_3)	.40	1.51	.85	.45		2.00
Tannin			1.29			
Total	100.00	100.00	100.00	100.00	100.00	100.00

*Dried and ground by R. E. Wood, Rutherford, Napa County, Cal.

Under this head, *nitrogen contents*, it is worth referring again to the large table to call attention to the distribution of the *nitrogen* in the several portions of these fruits. First, then, it is readily seen that the flesh holds 85 per cent of all the nitrogen, leaving 15 per cent of it as waste, so far as food values are concerned. Second, the proportional distribution of the nitrogen in the pits of the prunes and apricots to the *kernels* and *shells* appears to rate on the whole about the same (12 to 1), although we note great variation in this respect in both fruits.

ASH COMPOSITION AND NITROGEN CONTENTS.

Contrary to statements in our previous publications (Bulletins Nos. 88 and 93 of this department), in which, according to European data, the orange stands second (grapes being first) among fruits in the quan-

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ANALYSES OF THE ASH OF PRUNES AND APRICOTS.

Number	Fruit.	Place of Production.	Percentage of Pure Ash	Composition of Pure Ash.												
				Potash	Soda	Lime	Magnesia	Peroxid of Iron	Br. Oxid of Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less excess of Oxygen due to Chlorine	Totals
	French Prunes.															
33	Whole fruit	Yuba City, Sutter Co.	.567	66.92	.92	6.27	5.56	1.70	.36	12.91	2.54	2.67	.43	99.98	.10	99.88
	Flesh		.523	70.72	.84	5.48	5.02	1.30	.18	11.16	2.40	2.44	.46	100.00	.11	99.89
	Pits		.751	24.63	2.13	15.04	11.58	6.13	2.38	29.49	4.13	5.33	.13	99.97	.03	99.94
3	Whole fruit	San José, Santa Clara Co.	.442	65.92	3.18	3.24	6.16	.85	.31	13.19	2.37	4.56	.19	99.97	.05	99.92
	Flesh		.434	69.50	3.07	3.01	5.33	.83	.17	11.56	2.13	4.30	.20	100.10	.05	100.05
	Pits		.582	24.01	4.53	6.04	16.26	1.14	1.90	32.98	5.40	7.88	.22	100.16	.05	100.11
42	Whole fruit	Pomona, Los Angeles Co.	.450	63.67	3.20	4.48	4.70	1.89	.51	16.14	3.15	1.99	.40	100.13	.10	100.03
	Flesh		.430	67.87	2.99	3.66	4.23	1.06	.33	15.23	2.84	1.46	.37	100.04	.09	99.95
	Pits		.850	20.60	5.33	12.96	9.72	10.41	2.31	25.92	4.63	7.41	.72	100.01	.18	99.83
53	**Average (whole fruit)**		.486	63.83	2.65	4.66	5.47	2.72	.39	14.08	2.68	3.07	.34	99.99	.08	99.91
	Royal Apricots.															
16	Whole fruit	Niles, Alameda Co.	.550	54.88	10.57	3.52	3.85	1.71	.21	13.86	2.95	7.85	.60	100.00	.15	99.85
	Flesh		.542	58.59	11.20	3.24	3.31	.77	.09	11.20	2.75	8.31	.58	100.04	.14	99.90
	Pits		.681	10.95	3.45	6.75	11.58	12.39	1.65	43.76	5.38	2.58	1.65	100.14	.40	99.74
28	Whole fruit	Pomona, Los Angeles Co.	.467	63.85	9.95	2.82	3.52	1.66	.54	12.33	2.32	2.62	.30	99.91	.08	99.83
	Flesh		.459	67.00	10.23	2.65	2.89	.97	.39	10.88	2.35	2.27	.28	100.11	.07	100.04
	Pits		.592	23.09	6.45	6.58	11.22	10.06	2.20	30.96	1.84	7.09	.51	100.00	.12	99.88
54	**Average (whole fruit)**		.508	59.36	10.26	3.17	3.68	1.68	.37	13.09	2.63	5.23	.45	99.92	.11	99.81

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tity of mineral matter withdrawn from the soil, we find that, weight for weight, the fig has *second* place, the orange *third*, and the prune, apricot, and plum *fourth* place; thus more than ever bringing before us the fact that we cannot safely use European results as a basis of comparison for our fruits.

Using as a basis the preceding table of this publication, those given in Bulletins Nos. 93 and 97, and the work upon our figs, we have prepared the following tabular view of the amounts, in pounds, of vital soil ingredients extracted by the different fruit crops (poor fruit alone) that are withdrawn from the soil by different crops.

Soil Ingredients Extracted from the Soil by Different Fruit Crops.

Fruits.	Total Ash. Pounds.	Potash. Pounds.	Phos. Acid. Pounds.	Nitrogen. Pounds.
Grapes.				
European—				
In each 1,000 pounds	8.80	5.00	1.52	1.70
Apricots.				
European—				
In each 1,000 pounds	4.90			.86
Crop of 30,000 pounds	147.00			25.80
California—				
In each 1,000 pounds	4.91	2.90	.64	1.94
Crop of 30,000 pounds	147.30	87.00	19.20	59.20
Prunes.				
European—				
In each 1,000 pounds	6.30	3.73	.95	1.22
Crop of 30,000 pounds	189.00	111.90	28.53	36.60
California—				
In each 1,000 pounds	4.86	3.10	.68	1.62
Crop of 30,000 pounds	145.80	93.00	20.40	48.60
Plums.				
In each 1,000 pounds (California)	5.35			1.81
Oranges.				
European—				
In each 1,000 pounds	6.07	2.78	.67	2.69
Crop of 20,000 pounds	121.40	55.60	13.40	53.80
California—				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60
Figs.				
European—				
In each 1,000 pounds	8.00	2.27	.10	2.27
Crop of 15,000 pounds	120.00	34.05	1.50	34.05
California (White Adriatic)—				
In each 1,000 pounds	7.81	4.69	.86	2.38
Crop of 15,000 pounds	117.15	70.45	12.90	35.70

California *prunes* thus appear to draw much less upon the mineral ingredients which have to be replaced by fertilization than the European; the latter, however, draw much more lightly than the former upon nitrogen. *Apricots*, both of California and European growth, stand about equal as to total mineral ingredients withdrawn; of nitrogen, the California fruit draws twice as much, showing the only very material difference in the relative proportions of the vital soil ingredients among themselves as far as these two fruits are concerned.

Potash.—In the ashes of prunes and apricots and in the orange, potash is seen to be the leading ingredient; comprising in the prunes and apricots fully three fifths of the whole ash, and in the orange at least one half. In its distribution as between pits and flesh, the greatest difference is shown in the European prune; for apricots we have no

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foreign data. Although potash constitutes so large a portion of the ash of these fruits, its replenishment to the soil will be delayed long beyond the addition of other fertilizing ingredients; most California soils are naturally so well stocked with available potash that the current demand will be adequately supplied for many years.

Phosphoric Acid seems not to be so heavily drawn upon by California fruits as by European. Its distribution between pits and flesh, also, is not quite so variable as that of potash. Since our soils usually contain a limited supply of phosphoric acid, the prune and apricot as well as the orange orchards will require *phosphates* first when fertilizers are used.

Nitrogen.—Among our pitted fruits the apricot leads in its demand upon the soil for this substance, plums being quite the average of the apricots and prunes, and resemble very much the orange in this respect. Thus we find, for the southern localities especially, the same necessity of an early replacement of nitrogen in pitted fruit as for orange orchards; and partly for the same reason, viz., that California soils are usually not rich in their natural supply of this substance.

Of the other ash ingredients, it will be seen that *lime* is quite constant, although much less in amount (for prunes) than European standards show. Especially is this difference seen in the comparison of the ash analyses of the flesh and pits. In the orange ash the lime content far exceeds that of either the prune or apricot; accordingly, as our soils generally contain plenty of lime, even for oranges, we would rarely expect to fertilize with a view to its replacement. *Soda* is seen to be much higher here than in European analyses of the ash of the prune; this is probably explained by the fact that California soils, like those of other arid regions, contain much more soda than the European.

ADDITIONAL PROXIMATE ANALYSES OF PRUNES AND APRICOTS (CROP OF 1893); SAMPLES SENT BY GROWERS FOR ANALYSIS.

The work here reported was performed at the request of the growers of the several fruits, and was done after the preparation of the above paper.

No. 60. *Dried French Prune*, from Wrights Station, Santa Clara County; grown by W. H. Aiken, and received January 16, 1894. A fair sample of dried French prunes, of average size and sweetness.

No. 56. *Petite d'Agen*, from Arroyo Grande, San Luis Obispo County; grown by King Bros. The sample arrived here September 16, 1894. It was rather irregular in shape—flat on one side and bellied or rounded on the other, but of good size, and with a light purplish-brown skin. Flesh was rather dry and only fairly sweet for the variety.

No. 57. *Phillia d'Agen*, from Arroyo Grande, San Luis Obispo County; grown by King Bros., and received September 16, 1893. A nearly round-shaped fruit, with purplish-brown colored skin. It is a clingstone, with golden yellow and juicy flesh.

No. 59. *French Prune*, from Manton, Tehama County; grown by Woodward Bros. An average fruit of this variety, and was received October 3, 1893.

No. 58. *Pacific Prune*, from Mount Tabor, Oregon; grown by T. V. Sluman, and received September 26, 1894. This fruit is quite as large

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as an Hungarian prune, but much more nearly round in shape; the color, too, is even darker purple than that of the French prune, and the skin is marked with spots. The flesh is juicy and golden yellow in color.

No. 55. *Prune*, from Arroyo Grande, San Luis Obispo County. The variety is unknown; it was grown by King Bros., and received for examination September 4, 1893. Form oval, symmetrical; color dark purple, but cloudy; flesh greenish-yellow, and rather dry; pit free, oval, rather thin and smooth. This fruit, while nearly as large as a French prune, still has a much larger pit, and cannot compare with it in sweetness and flavor.

No. 54. *Hemskirk Apricot*, from Bakersfield, Kern County, grown by James M. Hunter, and received July 14, 1894, in good condition, and fully ripe.

The following table gives the results of the analysis of the fruits described above:

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PROXIMATE ANALYSES OF PRUNES AND APRICOTS—CROP OF 1893.

Number	Variety.	Place of Production.	Name of Grower.	Date of Receipt and Analysis.	Average Weight, in Grams*	Number per Pound	Flesh, Per Cent.	Pits, Per Cent.	Flesh.		Juice.		Sugar.	
									Juice (pressed), Per Cent	Pulp (pressed), Per Cent	Total Sugar by Copper (inversion), Per Cent.	Acid, in terms of Sulphuric (SO$_3$), Per Cent	In Fresh Flesh, Per Cent.	In Fresh Fruit, Per Cent.
	Prunes.													
60	French Prunes—Dried	Wrights Station, Santa Clara Co.	W. H. Aiken	Jan. 15, '94	10.0	45.0	88.0	12.0	.....	.....	.....	.....	†55.00	†48.40
56	Petit d'Agen	Arroyo Grande	King Bros.	Sept. 16, '93	24.5	18.0	94.9	5.1	71.7	28.3	17.50	.....	12.80	12.16
57	Phillia d'Agen	Arroyo Grande	King Bros.	Sept. 16, '93	25.5	17.8	95.1	4.9	75.3	24.7	17.20	.....	12.90	12.30
59	French Prunes	Manton	Woodward Bros.	Sept. 25, '93	26.7	16.0	93.2	6.8	80.0	20.0	19.00	.54	15.20	13.96
58	Pacific Prune	Mt. Tabor, Oregon	T. V. Sluman	Sept. 26, '93	69.0	6.5	97.1	2.9	85.0	15.0	11.03	.47	9.50	8.60
55	Unnamed Prune	Arroyo Grande	King Bros.	Sept. 4, '93	21.0	21.5	92.4	7.6	78.3	21.6	7.50	.....	6.50	6.00
	Apricots.													
54	Hemskirk	Bakersfield	J. M. Hunter	July 14, '93	66.0	6.8	93.7	6.3	83.0	17.0	10.50	.50	9.87	9.29

*30 grams are equivalent to 1 ounce. †These results are of course upon dried flesh and fruit.

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To save too much cross-reference to figures given in table on p. 260 of this report, and those for the fruits lately examined, we prefer to explain a few of the points relating to both sets of figures.

The analysis of the dried French prune, No. 60, yields average results for this variety, in weight, pit, flesh, and sugar percentages. The Petit d'Agen and Phillia d'Agen, Nos. 56 and 57, respectively, while average-sized, are not as sweet, *i. e.*, do not contain within 3 per cent as much sugar in the fruit as the average French prune. The prune from Manton, No. 59, is only 1.30 per cent below the average in sugar (whole fruit). The unnamed variety, No. 55, from Arroyo Grande, falls very much below the French prune in sugar in the fruit—nearly 10 per cent—and so cannot be classed with that variety, although its appearance is somewhat favorable for that. The Pacific prune, No. 58, from Mount Tabor, Oregon, an extensively advertised fruit, is smaller than the Hungarian prune from San José, No. 7, possesses a somewhat smaller pit—0.7 per cent less—is more juicy, and contains about 2 per cent less sugar.

The Hemskirk apricot, No. 54, from Bakersfield, stands quite the average, in all respects, when compared with the other southern-grown apricots; the apricots grown in Central California appear to be somewhat sweeter, viz.: 11.50 per cent, as against 9.70 per cent sugar for the southern fruit.

GENERAL SUMMARY OF RESULTS.

PERCENTAGES OF FLESH AND JUICE IN THE WHOLE FRESH FRUIT AND OF THE NUTRIENTS, WATER, ETC., CONTAINED IN THE FRESH EDIBLE PORTION OF SOME CALIFORNIA FRUITS.

From the foregoing tables of fruit analyses and the records, we have attempted to indicate in the following tabular summary the amount and the composition of the *edible portion* of the different fruits examined at this Station throughout the last three or four seasons. Some of the ingredients (*fat*, *crude fiber*, and some of the *carbohydrates*) have been left undetermined, for the simple reason that other parts of the work have been more important and took up the greater portion of our time. Because of this, we will not at present try to furnish any figures for the potential energy of these foods.

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AMOUNT AND COMPOSITION OF THE EDIBLE PORTION OF SOME CALIFORNIA FRUITS.

Fruits.	Number of Analyses.	In Whole Fruit.		Edible Portion.				
		Flesh, Per Cent.	Juice, Pressed, Per Cent.	Water, Per Cent.	Nutrients.			
					Protein (N. x 6.25), Per Cent.	Fat, Fiber, and Carbohydrates less Sugar, Per Cent	Sugar, Per Cent	Mineral Matters (Pure Ash), Per Cent.
Oranges	13	73.0	52.00	88.30	.760	*3.840	7.10	-------
Lemons†	22	71.0	45.50	-------	-------	-------	1.63	-------
French Prunes	10	94.2	74.20	75.15	.944	3.641	19.70	.586
All Prunes	20	94.2	74.20	80.20	.848	2.368	16.11	.474
Plums	3	95.2	71.00	78.40	.996	6.833	13.25	.524
Apricots	11	93.9	84.50	85.07	1.042	1.477	11.93	.477
Nectarines	1	93.4	85.00	82.90	.625	.855	15.13	.490
Figs	28	100.0	77.65	79.11	1.522	3.261	15.53	.577
Grapes	3	100.0	79.00	80.12	1.256	1.624	16.50	.500

*Contains the ash.

†The whole fruit yields: Water, 85.04 per cent; organic matter, 14.42 per cent; ash, 0.535 per cent. (Nitrogen on whole fruit, 0.152 per cent, corresponds to 0.95 per cent protein.)

The edible portion of the pitted fruits named above rates at nearly 94 per cent of the whole fruit, leaving the citrus fruits with about 72 per cent flesh—some 20 per cent behind in this respect. For this part of our study we can consider the fig and grape as standing first, it being ordinarily nearly all edible, or that it does not contain waste material. When the water percentages are examined it appears that the French prunes have the least water-content, 75.2 per cent; nearest to this the plums stand, with 78.4, and the figs next, with 79.10 per cent; oranges (and doubtless lemons), with 88 per cent of water, again rating poor in comparison with the pitted fruits.

Coming now to the *nutrients* as given above (protein, or flesh-forming substances; sugar, the chief carbohydrate in these fruits; and the mineral matters or pure ash), we find interesting facts, some of which have been alluded to in previous papers relating to fruits. The fig has *first* place among the fruits examined here in regard to its content of protein matters, *one half* as much again as either the apricot, plum, or prune, and *twice* as much as the orange, lemon, or nectarine; however, the grape follows the fig rather closely. The range in average protein materials is from 0.63 per cent in the nectarine to 1.522 per cent in the fig; individual samples of figs show in some cases very much higher percentages—2.587 being the highest yet returned.

Sugar, the principal carbohydrate, varies from 19.70 per cent in the flesh of the French prune to as low as 1.65 per cent in the lemon; the orange having 7.1 per cent, the apricot about 12.0 per cent; figs, nectarines, and all prunes and grapes, upwards of 15.0 per cent of sugar.

The amount of ash, or mineral matters, shows no sensible variation from one half of one per cent in all the fruits so far studied.

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ASH, AND ITS PERCENTAGE COMPOSITION IN CALIFORNIA FRUITS.

In the different fruit bulletins (Nos. 93, 97, 101, 102) and reports we have put forth the analyses of the ash of our fruits and used the figures mainly to give the amount of mineral matters withdrawn from the soil, and to show how much of the vital soil-ingredients must be added to the soil to replace them.

Collected in the following summary will be seen the averages of the amount and composition of ash in the fresh fruit of the grapes, oranges, lemons, prunes, apricots, and figs that we have had time to study.

The fig therefore contains, according to this showing, the highest amount of ash; in the three samples completely analyzed, 0.612 per cent, and for twenty-eight samples an average of 0.577 per cent. The orange shows the least amount of ash, 0.432 per cent, and the grapes, lemons, prunes, and apricots all stand so nearly at 0.500 per cent of ash that the differences are not worth noting.

Percentages of Potash.—This substance (potash), as is well known, predominates in the ash of fruits, making up from one half to nearly two thirds the whole; exceeding in the *prune* ash that of the other fruits. By the above showing it contains 63.83 per cent, or over 4.5 per cent more than the next highest in potash—the apricot ash, with 59.36 per cent. The fig ash, with 55.83 per cent, stands next, then the grape ash, with 50.95 per cent, and lastly orange and lemon ashes, with upwards of 48.0 per cent of potash.

Percentages of Soda.—This ingredient, while unimportant, shows rather greater variation, even for same fruits. In the above summary it runs from 1.76 per cent in ash of lemons to 10.26 per cent in apricot ash; grape ash being next to the highest, with 6.32 per cent soda.

Percentages of Lime.—This valuable substance shows much greater differences than either the potash or the soda; for the *lemon* ash, with 29.87 per cent of lime, contains nearly *ten* times more than the apricot ash, with 3.17 per cent of lime; the ashes of prunes and grapes have only somewhat over 4 per cent of lime. Next to the lemon comes the orange ash, with 22.70 per cent of lime—over twice as much as the fig ash contains.

Percentages of Phosphoric Acid.—This highly important portion of the ash of fruits is quite constant in the majority of the ashes; lemon ash containing the least amount, 11.09 per cent; orange and fig ashes, over 12.0 per cent.; apricot ash, 13.0 per cent, and prune ash, 14.0 per cent. Grape ash leads in phosphoric acid, averaging over one fifth of the whole ash, or 21.24 per cent.

Percentages of Magnesia, Peroxid of Iron, Oxid of Manganese, Sulphuric Acid, Silica, and Chlorine.—Like the soda, these ingredients are rated as unimportant and show but few *wide* differences. The *peroxid of iron* in the lemon ash, 0.43 per cent, is from one sixth to one half that in some of the other ashes. *Silica* ranges from 0.65 per cent in the citrus fruit ashes to as much as 5.20 per cent in the ashes of apricots and grapes. *Chlorine* in the prune ash is but 0.34 per cent; that in the fig ash is over six times as much, or 2.05 per cent.

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AMOUNT AND COMPOSITION OF THE ASH OF SOME CALIFORNIA FRUITS.

Whole Fruit.	Number of Analyses	Percentage of Pure Ash.	Composition of the Pure Ash.												
			Potash	Soda	Lime	Magnesia	Peroxid of Iron	Br. Oxid of Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less Excess of Oxygen, due to Chlorine	Total
Grapes*	5	.500	50.95	6.32	4.96	3.04	2.73	.36	21.24	4.28	5.31	1.54	100.73	.33	100.40
Oranges	9	.432	48.94	2.50	22.71	5.34	.97	.37	12.37	5.25	.65	.92	100.02	.20	99.82
Lemons	2	.526	48.26	1.76	29.87	4.40	.43	.28	11.09	2.84	.66	.39	99.98	.09	99.89
Prunes, French	3	.486	63.83	2.65	4.66	5.47	2.72	.39	14.08	2.68	3.07	.34	99.99	.08	99.91
Apricots, Royal	2	.508	59.36	10.26	3.17	3.68	1.68	.37	13.09	2.63	5.23	.45	99.92	.11	99.81
Figs	3	.612	55.83	2.38	10.90	5.63	2.19	.21	12.42	3.96	4.33	2.05	99.89	.44	99.45

*Analyzed by F. T. Bioletti, of this Station staff.

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ANALYSES OF BANANAS AND BANANA SOILS FROM THE SANDWICH ISLANDS.

By Geo. E. Colby.

This investigation was made for Mr. A. J. Campbell, of Honolulu, H. I., during the vacation of 1886, and is reported now, by his permission, in view of the interest attaching to this culture in California, both from the standpoint of the cultivator and the fertilizer manufacturer. Then, too, the report by Mr. Campbell upon fertilizer experiments recommended by Professor Hilgard and based upon the analyses of the soils and the ash of the leaves and fruit of the banana, is of interest.

Under the date of April 11, 1886, Mr. Campbell wrote to Professor Hilgard: "I take the liberty of sending you two samples of soils and their corresponding subsoils. My desire is to find out the fertilizer these soils require, in a general way, and what specially for a banana crop, which seems to be very exhaustive to the soil. The samples represent the two varieties of soil at and in the vicinity of my banana plantation, and were prepared as described in one of your University bulletins (No. 26). No. 1 was taken to a depth of 13 inches and the subsoil an additional 13 inches. No. 2 was taken to a depth of 12 inches and the subsoil an additional 13 inches. These samples come from a very dry district, where irrigation is necessary and the irrigating waters contain silicates of sodium and potassium. No. 2 seems to be a heavy adobe soil. Both crack when dry. No. 1 becomes very soft after rains, while No. 2 gets very sticky. No. 2 is a red, clayey-looking soil, which gives good crops of almost anything. The lighter-colored, No. 1, does not seem so fertile."

The soils were sampled and analyzed in accordance with the methods usually pursued in the Station laboratory, with the following results:

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ANALYSES OF SOILS AND SUBSOILS FROM THE BANANA PLANTATION OF A. J. CAMPBELL, HONOLULU, H. I.

	No. 1, Dark-Colored.		No. 2, Chocolate-Colored.	
	Soil. Depth, 0—13″.	Subsoil. Depth, 13″—26″.	Soil. Depth, 0—12″.	Subsoil. Depth, 12″—25″.
Coarse materials >0.5mm.	None	None	None	None.
Fine earth	All	All	All	All.
Analysis of Fine Earth.				
Insoluble matter	13.050	12.956	15.913	13.905
Soluble silica	26.755 } 39.805	25.129 } 38.085	23.072 } 38.985	26.027 } 39.932
Potash (K_2O)	.243	.221	.222	.409
Soda (Na_2O)	.123	.154	.062	.108
Lime (CaO)	.221	.187	.442	.241
Magnesia (MgO)	.517	.432	.685	.641
Br. ox. of manganese (Mn_3O_4)	.189	.126	.637	.680
Peroxid of iron (Fe_2O_3)	21.170	22.244	17.525	20.153
Alumina (Al_2O_3)	24.149	25.246	26.835	26.051
Phosphoric acid (P_2O_5)	.121	.205	.197	.129
Sulphuric acid (SO_3)	.005	.005	.004	.005
Carbonic acid (CO_2)				
Water and organic matter	13.722	13.416	14.362	12.061
Total	100.285	100.321	99.956	100.411
Humus	1.097		1.455	
Humus ash	.714		1.226	
Containing phosphoric acid	.047		.085	
Humus-nitrogen in 100 humus	6.580		6.200	
Humus-nitrogen in 100 fine earth	.072		.090	
Hygroscopic moisture absorbed at 13°C.	13.700	14.400	12.200	13.05

The above soil analyses are thus discussed by Professor Hilgard: "Contrary to my expectations the two do not differ widely, and are evidently of similar origin. It is curious that the darker colored soil, No. 1, actually contains less humus than No. 2, the red one, owing doubtless to the different condition of the humus. Of this substance, however, there is in both an adequate supply. As regards the other ingredients, potash is in quite small supply, when taken in connection with the supply of lime. The whole analysis indicates that these two substances should be supplied to the soil. Phosphoric acid is not only in adequate total supply, but so large a proportion of it is in an available state that the use of phosphate fertilizers is not at present indicated and would probably not pay for some time to come."

ANALYSES OF LEAVES AND FRUIT OF THE BANANA.

For the analysis of the leaves, the wrapping of a bunch of fruit sent by Mr. Campbell was used. The dried leaves were calculated to fresh ones from the result of a drying experiment with the leaves taken from a hot-house plant.

The *sand* held by the leaves mechanically was removed from the ash by treating the *insoluble residue* with carbonate of soda solution. For

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the analysis of the fruit a fresh sample of Sandwich Island banana was bought in the San Francisco market, as soon as possible after the arrival of the steamer.

The tables below show: (1) The *proximate analysis* of the *fruit* (results are given upon dried and fresh substance); (2) The analysis of the *ash* of the *fruit*, comprising the percentage composition with the same referred to *fresh* and *dried* fruit; (3) The proximate analysis of the *leaves* of the banana with figures arranged so as to give the returns upon the substance *dried at 100° C.*, *air-dried*, and *fresh*, and in addition the parts, in pounds, these figures hold when calculated upon the weight (9.3 pounds) of fresh leaves used as wrapping for one bunch of bananas.

1. PROXIMATE ANALYSES OF THE FRUIT OF THE BANANA, FRESH SAMPLE PROCURED IN THE SAN FRANCISCO MARKET.

	Dried at 100° C.	Fresh.
Water	.....	82.060
Carbohydrates, etc.	90.624	16.256
Albuminoids (crude protein)*	3.369	.606
Ash	6.007	1.078
Totals	100.000	100.000

*Determined by the soda-lime method.

2. ANALYSIS OF THE ASH OF THE FRUIT.

	Percentage Composition of the Ash.	Composition of the Ash. Referred to	
		Fruit Dried at 100° C.	Fresh Fruit.
Silica (SiO_2)	5.512	.332	.0595
Potash (K_2O)	63.066	3.788	.6800
Soda (Na_2O)	2.348	.141	.0250
Lime (CaO)	.860	.052	.0093
Magnesia (MgO)	2.940	.177	.0317
Br. ox. of Manganese (Mn_3O_4)	.115	.007	.0010
Peroxid of iron (Fe_2O_3)	.229	.014	.0034
Alumina (Al_2O_3)			
Phosphoric acid (P_2O_5)	1.620	.098	.0175
Sulphuric acid (SO_3)	2.329	.139	.0250
Chlorine (Cl)	26.930	1.618	.2905
Totals	105.949	6.366	1.1429
Less oxygen corresponding to chlorine	6.087	.365	.0656
	99.862	6.001	1.0773

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3. PROXIMATE ANALYSES OF THE LEAVES OF THE BANANA FROM THE PLANTATION OF A. J. CAMPBELL, HONOLULU, H. I.

	Leaves of the Banana.			
	Dried at 100° C.	Air-dried.	Fresh.	†Weight in lbs. of Ingredients of the Leaves.
Water	----------	11.443	83.963	7.862
Organic matter (not nitrogenous)	79.31	70.235	12.723	1.189
Albuminoids (crude protein)*	9.25	8.180	1.490	.139
Ash	11.44	10.142	1.834	.171
Total	100.00	100.000	100.000	9.341

*Determined by the soda-lime method.
†Calculated upon the weight (9.34 lbs.) of fresh leaves used to wrap one bunch of bananas.

4. ANALYSIS OF THE ASH OF THE LEAVES OF THE BANANA.

	Percentage Composition of the Ash.	Composition of the Ash referred to Leaves.			Parts of a Pound of Ingredients of Ash, calculated on 9.341 lbs.
		Dried at 100° C.	Air-dried.	Fresh.	
Silica (SiO_2)	23.900	2.734	2.418	.438	.0409
Potash (K_2O)	27.552	3.151	2.852	.505	.0472
Soda (Na_2O)	.304	.035	.031	.006	.0005
Lime (CaO)	17.882	2.046	1.809	.328	.0306
Magnesia (MgO)	8.146	.932	.824	.149	.0139
Br.ox. of Manganese (Mn_3O_4)	.573	.066	.058	.011	.0010
Peroxid of iron (Fe_2O_3)	3.177	.363	.321	.058	.0054
Alumina (Al_2O_3)					
Phosphoric acid (P_2O_5)	.638	.073	.065	.012	.0011
Sulphuric acid (SO_3)	3.413	.391	.345	.063	.0058
Chlorine (Cl)	18.550	2.122	1.877	.340	.0318
Total	104.135	11.913	10.600	1.910	.1782
Less oxygen corresponding to chlorine	4.180	.478	.423	.077	.0072
	99.955	11.435	10.177	1.833	.1710

Of these results Professor Hilgard says: "The analysis of the leaf ash shows that potash, lime, and chlorine are the ingredients chiefly drawn upon by the leaves, but the total amount of these contained in the wrapping of a bunch is only 0.17 of a pound, and the potash so withdrawn only amounts to half a tenth (0.05) of a pound per bunch.

"The ash of the fruit itself is very much less than that of the leaves, but it contains much more of the important elements; 63 per cent of it is potash, which, with chlorine, forms the predominant ingredient—potassic chlorid. Assuming the average weight of a bunch of bananas to be 80 pounds, each bunch carries with it 0.86 of a pound of ash, of which 0.55 is potassic chlorid or commercial muriate. Taking 500 as the average number of bunches of fruit per acre (planting 9 by 9 feet), there will be extracted 275 pounds of potash by each crop, or, with the leaf wrappers, nearly 300. This draft upon the relatively small potash supply in the soil is, in all probability, the chief cause of the falling-off of the production. But there is another point: While the fruit is not

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very rich in albuminoids, the leaves contain nearly as much as average meadow hay. The wrappings of each bunch of bananas carry away, say, 0.15 of a pound of the same, each bunch of bananas about 0.25 of a pound, or over two fifths of a pound for each bunch packed. This is quite a heavy draft per acre; when it is multiplied by the number of bunches, it is over ten times as much as for a wheat crop, for example. Evidently, some nitrogenous fertilizer should be supplied.

"*Conclusions.*—The fertilizers indicated by the analyses of the soils as well as by that of the fruit and leaves are potash salts, or *kainite* on the one hand, and Chili saltpeter on the other. Kainite would best be imported direct from Germany, the other from Chili or from this market. As to the quantity to be used per acre, the soil in its present condition, according to the analyses, will supply one half of the potash required by the crop. The deficiency, the other half, must be furnished by fertilizers in order to obtain a maximum (full) crop. A preliminary experiment with a smaller proportion should be tried. For example, a mixture of 500 pounds of *muriate* and 200 pounds of tankage, dried blood, or some other nitrogenous fertilizer, might be tried per acre, with lime in the shape of coral sand from the beach, or such other matter as may be convenient or cheap. Above all, whatever offal may be available, including stable manure, should be returned to the soil. The chlorine needed will also be supplied by the fertilizers recommended above, but as an additional experiment a dressing of salt may be applied."

The report from Mr. Campbell upon his experiments with fertilizers for bananas reads: "Potash I consider the proper fertilizer for bananas, although the results obtained on soil No. 1 (dark-colored) were not as good as those obtained on No. 2 (chocolate-colored), upon which I have fair, in fact, good success." There is nothing in the report to the effect that any lime or nitrogenous fertilizer was used in the experiments.

OLIVES AND OLIVE OILS.

By Arthur P. Hayne.

DESCRIPTIONS OF OLIVE VARIETIES.

In presenting descriptions of olive varieties, we do not mean to claim that they are complete or perfect; there are none other more complete in existence, so far as known. What has been written on the subject is, for the most part, scattered through many works in foreign languages, and is not available, least of all to the olive-growers of California. Constant requests for information reaching the College of Agriculture seem to render it expedient to publish what is at hand, with the intention to correct hereafter any errors, and to enlarge the work as fast as we may be able to obtain definite information.

In making this compilation we have taken all available data from French, Spanish, and Italian works, together with personal observations in Europe and California, giving all that was deemed reliable.

The University has some fifty-five varieties growing (though not all bearing) at the five culture stations connected with the College of Agriculture. Besides these we have been able to avail ourselves of the public-

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spirited aid of various olive growers, who have sent us samples of olives for experiment and analysis. It is to be hoped that all those who grow olives (especially new varieties) in new regions will send samples to the Agricultural Experiment Station at Berkeley, so that the work of investigation may be carried on along the lines already laid down.

The following brief description of olive varieties, oil mills, etc., must then be taken as answers to questions that come to us daily, not as an attempt at a complete or original work on olives.

The analyses of foreign olives in the following descriptions were made in France by Professor Bouffard, of the Montpellier School; those from California by George E. Colby in the Viticultural Laboratory of the University Experiment Station.

LUCQUES.

SYNONYMS: *Olive de Lucques, Lucquoise, Oliverolle, Oderante; Olea minor, lucensis, fructu oblongo, incurvo, odorato* (Tournefort); *Olea europæa ceratocarpa* (Clemente).

This variety is frequently confounded with the Picholine, with which it presents certain analogies of form. There is no good reason, however, for confusing the two.

TREE of medium vigor and development; semi-erect grower; *trunk* cylindrical; the *bark* detaches in long strips so readily that the trunk is sometimes denuded of its covering; main branches semi-erect or horizontal; general appearance is always that of a vase; *suckers* not numerous; *branches* vigorous, long, straight, erect, or horizontal, with abundant young growth growing at right angles, drooping when young, and of a clear gray color; *wood* in the form of a hexagon, especially at the extremities of the young growth; *eyes* prominent.

LEAF medium long and narrow (mean length, 6 to 9 centimeters; width, $\frac{3}{4}$ to 1 centimeter.) Superior surface clear green, slightly red. Inferior surface with slight dirty white deposit. *Nerves* not well defined, even on the superior surface. *Petiole* long, thin, and bent over. The leaf has its edges folded over, and is not equally divided by the main nerve. It is not heavily clothed with leaves.

FRUIT frequently single, the greater part distributed at the base of the branches of a year's growth. *Peduncle* long, thin, inserted in a very slight depression in the fruit. *Stigma* persistent in a well-defined umbilicus.

FRUIT medium large (mean length, $2\frac{1}{2}$ to 3 centimeters; thickness, $1\frac{1}{4}$ to $1\frac{1}{2}$ centimeters), crescent-shaped, the surface opposite the curvature almost rectilinear. The form is very characteristic. In *color* it passes from a clear green to a shiny blue-black with very little bloom. *Skin* thin, and *pulp* abundant; *pit* medium large, the same form as the fruit; maturity early.

Analysis of the Lucques.

	France.	California.
Number of olives in 100 grams		
Percentage of pit in whole fruit	20.00	30.00
Percentage of flesh in whole fruit	80.00	70.00
Percentage of oil in fresh flesh	21.55	13.70

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From this comparison it would seem as though the Lucques did not prosper in California as well as in France. However, the samples of Lucques analyzed at the University were so shriveled that it is not a fair test. Making due allowance for loss, we are safe in supposing that there is but little real difference.

This variety is not widely known, except in localities where the chief industry is that of pickling the olive. Some claim that it is of Italian origin, but it is well known in Spain, where it does very well, having the same general characters as the Lucques elsewhere. It is a variety of medium vigor and longevity.

Though it resists well the cold, it requires hot summers to mature well. It is found in all sorts of localities, but would seem to do best on hillsides where the soil is deep. On dry, shallow soils it is a failure. On the French market the olives command a higher price for pickles than any other variety.

Tablada says of it: "It needs vigorous and repeated pruning to yield annual crops."

In California there seem to be several plantations of varieties wrongly named Lucques. We call special attention to the description above.

NEVADILLO BLANCO, OR MOIRAL.

SYNONYMS: *Olivo Doncel Zorzaleña*, *Moradillo* (Tablada). *Moiral*, *Mourau*, *Mouraou*, *Moure*, *Mouraude*, *Mourescale* (Herault). *Mouraoudo* (Aude). *Olea europea argentata*. *Moureau*, *Mourelt*, *La More* (Gard). *Mouretto* (Aix-en-Provence). (?) *Ribière*, (?) *Ribiè*, (?) *Roubèiro* (Provence).

TREE vigorous, large, spreading grower; *bark*, gray; *suckers* ordinarily numerous; *foliage* when young very vigorous, inserted at an acute angle; *color*, at first dirty greenish-gray on the two-year-old wood; *wood* cylindrical, quadrangular only at the extremities of the young branches; *eyes* medium prominent.

LEAF medium long and wide (mean length, 6 to 7½ centimeters; width, 1¼ to 1⅝ centimeters). Superior surface shiny, deep green; inferior surface with thick deposit. Principal nerve well marked on both faces. The leaves are very plentiful, forming a thick covering to the tree.

FRUIT regularly distributed along the entire length of the branches, most frequently single, sometimes in pairs; *peduncle* short; *pedicel* long, inserted in a well-marked depression in the berry; *stigma* not apparent in well-marked umbilicus. An olive of under the medium size or small. In California it seems to be well adapted to its soils, etc., and is larger than in Europe (mean length in Europe, 1½ to 1⅞ centimeters; width, 1¼ to 1⅜ centimeters). Form almost perfectly regular, with the exception that it is slightly obtuse at the two extremities. *Pit* large, of the same shape as the berry, with a groove the entire length of the pit. The olive is of a shiny, deep black color, with very little bloom. *Skin* thick; *pulp* abundant, of a wine-red color.

The Nevadillo Blanco came to California from Spain; probably there are importations from other countries also. From the descriptions we have of it, we are led to suppose that it is more vigorous and productive in California than in Europe. But it is the first to suffer from frost. The analyses made at the University point it out as one of the best adapted varieties of the State. Here it is a remarkably regular bearer. Professors Viala and Degrully, of the Montpellier School, say of it: "It is one of the most esteemed varieties of the Languedoc, formerly exten-

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sively cultivated; its chief fault being that its early maturity necessitated a separate harvest. As this variety is an exceptionally regular bearer, it is to be recommended for large plantations where its early maturity would not cause any difficulty."

Analyses of Nevadillo Blanco.

	France.	California.	Spain.
Number of olives in 100 grams	78	36	20
Percentage of pit in whole fruit	23.50	20.55	----------
Percentage of flesh in fresh fruit	76.50	79.45	----------
Percentage of oil in flesh	13.78	24.83	----------

From this comparison we see that the Nevadillo is a far more valuable variety in California than in France, as the figures are the averages from nine samples of Nevadillo Blanco grown in almost as many parts of the State. There is still a doubt if the Moiral of France is the Nevadillo Blanco of California. The resemblance is very striking, and one of the names of the Moiral in France is the Nevadillo Blanco. The *difference in size and richness in oil is not enough to lead us to suppose that the two varieties are not identical.* The difference in soil, climate, and care are alone able to account for this discrepancy in analyses. We have in California the same variety varying 20 per cent in oil contents; so we must not be too hasty in doubting the identity on account of a difference of 10 per cent in richness.

According to Tablada, the Nevadillo Blanco of Spain is the Moiral of France; but it is a native of Spain, and would seem to thrive there better than in France. It certainly does remarkably well in California in a great variety of soils and locations. While it is an excellent oil olive, it is not so well adapted for pickles as some others on account of its size, being smaller than the average Mission, which may be taken as a fair standard of comparison, being so well known in this State.

ATRORUBENS.

SYNONYMS: *Saillern, Saillerne, Sagerne* (at Nimes), *Olea minor, Rotunda, Rubro-Nigriens* (Tourneford).

This is a Southern French variety, known almost everywhere to-day as *Saillern*; but as it seems to be well known in California under the name of *Atrorubens*, it has been deemed wise to adopt this one of its synonyms in order to avoid unnecessary confusion.

TREE very vigorous, medium-sized or large; spreading grower; *trunk* very thick, enlarged at the base; *bark* peels off in fine longitudinal strips of a blackish color; *suckers* very numerous. (This variety is said to sucker more than any other); *foliage* tolerably vigorous, not generally very thick, and makes a large shoulder where it branches out; *color* dirty yellow; *eyes* prominent.

LEAF regular, short, relatively wide (mean length, 6 to 7 centimeters; mean width, 1¼ to 1½ centimeters). Superior surface shiny, clear green; inferior surface with abundant dirty white deposit; *nerves* well marked on the superior surface; *petiole* thick, short, twisted so as to cause all the leaves to be on the same side of the twig. The leaf is almost flat. Very few leaves in the interior of the tree.

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FRUIT mostly single, sometimes in clusters of two on two-year-old wood; *peduncle* long, fruit drooping; *stigma* persistent in a well-defined umbilicus; *fruit* rather small (mean length, 1 to 2 centimeters; thickness, 1 to 1¼ centimeters). *Form* almost oval, slightly elongated; very slight swelling on one side; deep black with abundant bloom. *Skin* thin; *pulp* abundant, fleshy, with a deep wine-red juice; *pit* large, being the same shape as the berry; *maturity* medium.

This variety is quite delicate and very sensitive to cold, hence is not found in very old plantations in Europe, having been killed off during the very cold seasons that sometimes occur. It is moderately productive, and bears a crop almost every year when properly adapted to the climatic conditions.

The quality of its oil is excellent.

Analysis of Atrorubens.

	France.	California.
Number of olives in 100 grams	41	28
Percentage of pit in whole fruit	22.15	16.75
Percentage of flesh in whole fruit	77.82	83.25
Percentage of oil contained in fresh flesh	17.91	22.85

The above analyses show that the average Atrorubens in California is a larger and richer olive than in Europe. It has less pit, more flesh, and this flesh contains more oil. From data thus far at hand we are led to believe that it is more prolific in California than in France. The above figures are averages of four analyses of olives grown near Montpellier, France, and two analyses of olives grown at Biggs and Fresno, California, respectively.

AMELLAU.

SYNONYMS: *Amenlau, Amenlaou, Amellenque, Amandier, Amellaude; Olea europea amygdalina* (Gouan). *Olea sativa, major oblonga, angulosa, amygdaliforma.*

TREE not vigorous, rarely reaching an advanced age. Semi-erect *grower*. *Trunk* small, twisted, frequently irregular; *foliage* slightly drooping; the general aspect of the tree is that of a ball; *suckers* very numerous; *branches* short, erect, or horizontal, not vigorous. Young branches generally horizontal, of an ashy-gray color; *bark* reddish; *wood* irregularly flattened at its extremities; *eyes* prominent.

LEAVES both short and wide (mean length, 4 to 6 centimeters; width, 1 to 1½ centimeters); upper surface olive green; lower surface with very slight silvery white deposit; nerves prominent on the superior surface only; *petiole* large, short, slightly bent over. The leaf is almost flat. The tree is but thinly covered with leaves.

FRUIT nearly always single, irregularly distributed; *peduncle* large, short, inserted in a deep depression in the olive; *stigma* hardly apparent; *fruit* very large (mean length, 2½ to 3 centimeters; thickness, 1½ to 2 centimeters), of irregular form, recalling that of the hull of a green almond (whence its name). It is more or less flattened, and has a prominent ridge passing over its two ends. The olive passes from a clear green to a very deep reddish-black, with considerable bloom, and a number of small whitish specks. *Pit* very large, irregular, with a depression at one end. *Maturity* medium early.

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This is a Southern French variety. It bears a very large berry, which makes it valuable for pickles; but on the other hand it is not productive in its native country, though in California it is said to be somewhat more prolific. It bears the greater part of its fruit on the *erect* branches of the secondary growth, thus requiring a different system of pruning from the other varieties. In Europe the fruit is picked green for pickles; but yields a small quantity of high-grade oil.

Analysis of Amellau.

	France.	California.
Number of olives in 100 grams	20	19
Percentage of pit in whole fruit	18.10	16.00
Percentage of flesh in whole fruit	81.90	84.00
Percentage of oil contained in fresh flesh	15.40	17.50

From the foregoing comparative tables it will be seen that at Biggs, in Butte County, California, the Amellau does better than the average of the same variety in France, the olive being larger, having less pit, more flesh, and 2.10 per cent more oil.

There was but one sample of this variety received at the University for analysis. This was donated by Hatch & Rock, of Biggs. It is desired to have samples of this variety from other localities.

MANZANILLO.

SYNONYMS: *Manzanilla, Rojal, Olea europea pomiformis* (Clemente), *Ampoulleau* (France).

The Manzanillo is one of the best varieties thus far introduced into California. It is a good bearer, quite regular in its crops, and at the same time equally well adapted for pickles or oil-making. This last quality gives it the advantage over other varieties for the small grower who cannot afford to make his own oil and wishes to be independent of the mill-owner. While it does well in many kinds of soils, it will not thrive in very dry shallow land; here, as in its native country (Spain), it requires plenty of moisture and a good strong soil. There seems to be more than one kind of Manzanillo now found in the orchards of the State. Though these certainly differ one from the other, there seems to be no good reason for attempting to rename these variations from the main type at the present moment, for the differences are unimportant and as yet not well studied.

TREE vigorous and hardy; *branches* long, curved, and light-colored. The secondary branches or twigs dry up when the fruit falls, which is very frequent.

FRUIT large and apple-shaped, sometimes slightly elongated. The chief difference thus far noted between the various kinds of Manzanillo is that in some cases the apple-like depression at the lower extremity of the fruit is more marked than in others, otherwise there seems to be little real difference.

It is found throughout Spain and in South France, where we are told it requires frequent regular pruning to insure regular crops.

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Analysis of Manzanillo.

	Spain.	California (Average).
Number of olives in 100 grams	15	21
Percentage of pit in fresh fruit	12.50	16.10
Percentage of flesh in fresh fruit	87.50	83.90
Percentage of oil in fresh flesh	----------	* 22.57

* Average of five lots.

From this comparison it will be seen that the Manzanillo does better in its native country than in California, so far as size is concerned; but we must bear in mind that the figures for California are made up of analyses of olives from many and all sorts of localities, while in Spain the variety has been long adapted to the soil that suits it best. Reference to the table will show that there are localities in California where the Manzanillo does fully as well as in Spain. There seems to be a difference in the minds of many growers as to the value of the Manzanillo. While in one locality it does remarkably well it has been found that in others, quite near, it is very irregular. As it is a variety extensively planted in California, this has led to lively controversies. Of course all varieties of olives must be adapted to special circumstances; and when the Manzanillo has been well placed, it would seem to be one of the best varieties to plant. It will certainly not do everywhere, but does not seem to be any more difficult of adaptation than any of the other varieties.

ROUGET (OR CAYON IN CALIFORNIA).

SYNONYMS: *Rougette, Rousseoun, Marveilletto, Pigan, Vermillau, Caillose, Cayonne, Rougealle; Olea rubicans* (Rozier).

This variety is known in California under the local name given it in the Toulon district, but as it is a well-known Languedoc variety, we shall follow the Languedoc nomenclature, as do the eminent authorities, Foëx, Viala, Flahaut, and Degruilly, of the National School of Agriculture at Montpellier, France.

TREE vigorous, attaining very large dimensions when favorably situated; *trunk* cylindrical; semi-erect grower; *bark* rough, and of a blackish gray color; *suckers* very numerous; *foliage* very plentiful, even on the old wood; vigorous, long, slender, and for the most part horizontal, or semi-erect; of a dull gray color; *eyes* prominent.

LEAF medium short and wide (mean length, 5½ to 6½ centimeters; mean width, 1 to 1¼ centimeters). Superior surface of leaf is dull green, with speckled edges. Inferior surface has a slight greenish deposit; *nerves* not prominent on either surface. The leaves are very numerous, forming a thick covering to the tree, inserted perpendicularly, and presenting only the upper surface to the view. This, together with the dark green color of the leaves, makes it easily recognizable from a distance.

FRUIT distributed evenly over the tree on the two-year-old wood, perhaps more abundantly at the base; single or in groups of 2, 3, or 4; *peduncle* medium long and thick, inserted in a slight depression; *stigma* not very well marked; *fruit* under the the medium size (mean length, 1½ to 2 centimeters; mean width, 1 to 1¼ centimeters); oval in shape, with slightly flattened ends. The fruit remains red for a long time, and even when it turns black there are numerous red specks on

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the surface. *Skin* is quite shiny, with little bloom. *Flesh* is abundant, and slightly wine-colored. *Pit* is medium-sized or small. *Maturity* quite late.

The Rouget is a very hardy variety, and is especially adapted to soils of a poor quality. It is found in dry rocky localities where all other vegetation is impossible. Ordinarily the tree attains large dimensions, and yields good regular crops, even when not favorably located. In Europe the coldest seasons never affect it. The Rouget yields oil of very good quality; it is also used for pickling, for which purpose it is picked when red.

We have no record of analysis of this variety from California. It is to be hoped that all those who have the Rouget or Cayon in California will send in samples for experiment.

Analysis of Rouget.

	France.
Number of olives in 100 grams	45
Percentage of pit in whole fruit	20.00
Percentage of flesh in whole fruit	80.00
Percentage of oil in flesh	15.27

From this analysis, it would seem that in France this variety yields much less oil than most of the varieties in California; but as we have shown, this is no test of its value in California, for others, which in Europe do no better than this, have proved to be most excellent in California.

PLEUREUR (CAILLET).

SYNONYMS: *Caillet, Cayé, Caillette,* or *Cayette* (Provence); *Cayon* (Herault); *Nostrale* (Nice, France, and Santa Barbara, California); *Olivier de Grasse* (Bernard).

Confused with the Pendoulier in some places under the names *Olivier pleureur, Cournaud, Cormaou.* We are led to believe that what we have in California under the name of Pleureur de Grasse is none other than the Caillet; so in order to avoid all possible confusion we accept the name Pleureur, provisionally.

TREE large and vigorous, pyramidal grower; *trunk* thick and cylindrical; *bark* dull gray; *suckers* numerous; *foliage* very abundant and vigorous, inserted at right angles, falling toward the ground after growing a few inches. Three years after pruning these branches become long enough to resemble those of the Pendoulier. Color of the young branches is light gray, turning to a dark gray with age.

LEAF medium or large (mean length, 6½ to 8 centimeters; width, 1 to 1½ centimeters); superior surface very dark green; inferior surface with very little greenish deposit; principal nerve very apparent on the superior surface; *petiole* short.

FRUIT regularly distributed, single or frequently in pairs, in which case the pedicle is long; *peduncle* medium, tolerably thick, dull green, inserted in a very slight depression in the berry. An olive of medium or above the medium size (mean length, 2½ centimeters; thickness, 1½ to 1¾ centimeters); *form* elongated ovoidal, slightly flattened at one side and swollen on the other; larger at the extremity, which is obtuse. *Color* violet black, with very little bloom; *skin* tender, shiny; *pulp*

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fleshy, colored by a violet juice. *Pit* large and of the same form as the olive, but more pointed.

The Caillet, or, as we shall call it, the Pleureur, is one of the most widely and extensively cultivated varieties of the Department of the Alpes-Maritimes. In the neighborhood of Grasse and Nice, it is the only variety now planted in the new plantations, or in place of trees accidentally killed. It is a remarkably vigorous grower, and in the neighborhood of Nice the trees have reached an extraordinary size, being as large as forest trees. It is a good bearer, and yields an oil of the very best quality. We have no records at hand as to this variety in California, but there is every reason to believe that it will do fully as well in this State as in the Riviera.

The Nostrale of Nice, France, was imported by the late Dr. Hall, D.D.S., of Carpinteria. We are led to believe that this variety is none other than the Pleureur. It seems to thrive excellently in Santa Barbara County, where we hear of several plantations. It should be cultivated especially for the quality of its oil.

PENDOULIER (CORNIALE).

SYNONYMS: *Corniale; Cornal, Cournal, Courniale Lucques Batarde* (Montpellier); *Courniaou, Cornaou* (Languedoc), *Courmeau, Corniau, Gourgnale, Plant de Salon; Courneaud, Cournial, Couchesal* (Gard); *Taglasca* (Genoa), *Pendulier* (La Ciotat, Var); *Salonenque* (Marseilles); *Oliva Cornicabra* (Tablada); *Olea Europea Rostrata* (Clemente).

TREE very vigorous, growing very large under favorable circumstances; its characteristic manner of growing recalls that of a weeping willow tree; *trunk* large and cylindrical; *bark* grayish black; *branches* generally inclining toward the ground. Young branches long and slender, falling perpendicularly toward the ground. Seen from a distance, it has the aspect of a weeping willow tree; *suckers* always very numerous; *foliage* when young, very long and slender, and numerous, inserted at right angles, but falling perpendicularly toward the ground. The color of the young branches is ashy gray, changing to a clear yellow, and afterwards passing to green on the older foliage. *Eyes* very prominent.

LEAF oval, elongated, narrow at the summit (mean length, 6 to 8½ centimeters; width, 1 to 1½ centimeters). Upper surface clear, shiny green; lower surface has a slight deposit of silvery gray color. The leaves are very abundant, and the covering of the tree is quite thick. The leaves are sometimes twisted on their petiole so as to expose the lower surface to the view.

FRUIT regularly distributed over the foliage, sometimes single, sometimes in groups of two and three, and in some cases even in bunches of five to six; *peduncle* long, slender, clear green, inserted in a depression that is not well marked; *stigma* and umbilicus not very apparent.

DRUPE of medium or more than medium size (mean length, 2¼ to 2¾ centimeters; width, 1 to 1¼ centimeters); irregular in form, recalling that of the dogwood berry, narrower at the top, slightly swollen on one side, and arched at the other, terminating abruptly in an obtuse point. The fruit passes from red at maturity to deep black; very little bloom; *skin* very shiny, slightly specked, and tender; *pulp* fleshy, abundant; *juice* reddish; *pit* large as compared with the size of the whole fruit; shape of pit about the same as the olive, but slightly more pointed. Variety is of the second period of maturity, *i. e.*, medium early.

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The Pendoulier, or Corniale, as it is generally known in France, is without doubt one of the most attractive olives of the Old World. It is known in California by its synonym on the Riviera; hence, we adopt that nomenclature to avoid confusion. Though it never forms plantations by itself, it is found throughout Southern France. It is an abundant bearer and quite regular in its crops. Although it is a vigorous and hardy tree, yet it prefers good soils to a stony shallow soil. It yields oil of superior quality, and like the Pleureur, deserves attention.

Analysis of Pendoulier.

	France.
Number of olives in 100 grams	58
Percentage of pit in whole fruit	24.60
Percentage of flesh in whole fruit	75.40
Percentage of oil in flesh	15.00

It is to be regretted that we were unable to obtain samples of this variety for experiment, for it is one of the most important and highly esteemed varieties of France, valued especially for the great delicacy of its oil.

PICHOLINE (TRUE PICHOLINE OF EUROPE).

SYNONYMS: *Pichouline*, *Pijouline* (throughout the Languedoc); *Saurine* (at Nimes); *Sausen*, *Saugen*, *Sauzin* (in the Department of Gard); *Saurenque* (Aix-en-Provence); *Plant de Sauren*, *Saurine*, *Punchado* (Marseilles); *Lucques Batarde* (Herault); *Pignola* (Genoa, Italy).

TREE of medium vigor and dimensions, spreading grower; *trunk* cylindrical; *bark* detaches easily from the trunk in irregular strips; *branches* grow horizontally, or with a slight upward inclination; very few suckers; *foliage* not vigorous, thick, growing at right angles to the main stem; of a yellowish-gray color; *wood* cylindrical or slightly flattened; *eyes* prominent.

LEAVES oval, frequently wider at the upper part; medium length and above medium width (5½ to 6½ centimeters in length, 1½ to 1⅞ centimeters in width). Upper surface dull, deep green; lower surface with slight dirty-white pubescence; well marked nerves on lower surface; *peduncle* thick, long, straight. The leaf is flat at the edges. Young branches are heavily covered with leaves.

FRUIT generally accumulated near the lower part of the wood of the year, single or in bunches of two. *Pedicels* very short; *stigma* persistent in a very slight umbilicus. *The fruit is above the usual size* (mean length, 2½ to 3 centimeters; width, 1 to 1½ centimeters). The form is ovoidal and elongated, but thickest near the peduncle, coming to a point near the lower extremity. It is very much *curved*, of a form intermediate between that of the Lucques on one hand and the Olivière on the other. The fruit passes from a clear green to a reddish-black; very little bloom, thin skin. *Pit* small, long, and pointed, being of the same shape as the fruit; maturity medium.

The true Picholine is widely known in France, especially in the neighborhood of Aix, Tarascon, and Marseilles, and throughout the Languedoc. It yields good crops with tolerable regularity. It is a variety of medium hardiness, but stands very heavy pruning. In France it is cultivated chiefly for pickles, although it yields a fair amount of high-

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grade oil. Its great delicacy makes it highly esteemed for pickles, being generally sold under the name of Lucques. It and the Verdale are the best eating varieties of the country.

In California the general belief seems to be that it is the same variety as the Oblonga. There is certainly a strong resemblance between the two, but we are not as yet ready to classify the two as identical. Below we give a comparative analysis of the Picholine made in Europe and the California Oblonga. From the figures alone I think it will appear sufficiently distinct to be classed by itself, knowing as we do, that in California we should look for larger fruit and more oil than in Europe.

Analysis of Picholine.

	Picholine, France.	Oblonga, California
Number of olives in 100 grams	23	40
Percentage of pit in whole fruit	10.86	19.00
Percentage of flesh in whole fruit	89.14	81.00
Percentage of oil in flesh	17.00	17.02

Aside from botanical differences, the analysis shows it to be unwise to call these two the same variety until the subject has been further investigated. It can be readily seen that it is distinct from the Redding Picholine, though some people are still found who claim that the Redding Picholine is the true Picholine of Europe. This error is so preposterous that no further attention need be paid to it.

VERDALE.

SYNONYMS: *Verdaou, Verdau, Vereau, Aventurier, Classen, Olea Viridula, Olea Media, Rotunda Viridia* (Tourneford), *Olivo Verdago* (Tablada).

TREE not vigorous, always remaining small; semi-erect grower; *trunk* slender, short, conical; *bark* reddish gray-green; shallow penetrating *roots*, hence frequently uprooted by winds; *suckers* few; grafts easily; *branches* not plentiful, erect or slightly inclined, growing at right angles; *color* dirty yellow, or clear green; *eyes* medium prominent.

LEAVES short, narrow (mean length, 4 to 6 centimeters; width, $\frac{1}{2}$ to $\frac{3}{4}$ centimeters); edges folded over, forming a trough; *nerves* prominent and of a clear green color; *petiole* short, slender, and twisted. All the leaves grow on the same plan, and form with the stems a very acute angle. The leaves are abundant at the extremities of the branches, but very scarce on other parts of the tree.

FRUIT single, never in clusters; *peduncle* medium length, slender, and dirty green; very slight depression in fruit for insertion of peduncle; large fruit, nearly round, slightly truncated at the summit; very green up to the period of maturity, then wine-red, and finally a deep black; very slight bloom at maturity; thick *skin*, fleshy, very little juice in berries; *pit* very large, of same shape as the fruit, with deep longitudinal furrows.

This is a Languedoc variety found throughout France, and highly esteemed for pickles; maturity very early. It is little used for oil, as the quantity of oil yielded is very small, and the berries rot very easily. It requires good, deep soils, and will not do at all in poor soils. It is attacked by frost, and is subject to "coulure," or the dropping off of the young fruit just after blossoming.

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Analysis of Verdale.

	France.
Number of olives in 100 grams	38
Percentage of pit in whole fruit	17.70
Percentage of flesh in whole fruit	82.30
Percentage of oil in flesh	22.83

None of the trees at the Culture Stations are yet in bearing, and we know of no bearing trees in the State, hence we have no data for comparison. It is earnestly requested of those having this variety in this country to send samples to the University for analysis; also any data concerning its growth, etc.

ROSE.

SYNONYMS: None known.

TREE medium vigor, medium development, spreading grower; *trunk* cylindrical; *bark* grayish.

LEAF elongated, oval lanceolate, medium sized (mean length, 6 to 7 centimeters; width, 1¼ to 1½ centimeters); superior surface shiny dark green; inferior surface greenish white, with a very slight deposit; *blade* thick, with slightly folded edges; one principal *nerve* well marked on both faces. The leaves are not very numerous and the covering of the tree is not very thick or heavy. The leaves are so twisted on the petiole as to stand off perpendicularly to the branch that bears them.

FRUIT: This variety bears its crop only at the base of the branches, either singly or in bunches of two and three; *peduncle* long or medium, inserted in a deep depression in the olive; *stigma* hardly apparent. An olive of medium or large size (length, 2¾ centimeters; width, 1½ centimeters). *Form* cylindro-conical, but flattened at one side and terminating in a point not at all sharp or long. The fruit passes from a red to a reddish-black color; slightly specked, and little bloom. *Skin* thin, *pulp* whitish, slightly colored by a rose-colored juice; *pit* large, of a form more elongated than the olive itself and sharper pointed. *Maturity* medium late.

This variety is but little cultivated in the Languedoc. It is a good bearer and quite regular in its crops. It is mostly used for pickles. It is not yet in bearing in California, so far as we know.

EMPELTRE.

SYNONYMS: None known.

This is a Spanish variety, of dwarfish habits; so named because of the remarkable ease with which it may be grafted, it being seldom, if ever, grown on its own roots. The word *empeltre* signifies "grafted." This variety is not widely known in Spain on account of its want of vigor, but is esteemed on account of the rapidity with which it comes into bearing, and its resistance to cold, which enables it to grow on the extreme limits of the olive regions in Spain.

TREE is not at all vigorous.

LEAVES are short and unevenly divided by the main nerve, which is not at all prominent and quite fleshy; superior surface is dark green; inferior surface is light green with a slight white deposit.

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FRUIT bell-shaped, medium-sized (mean length, 28 millimeters; thickness, 16 millimeters); *pit* is free from the pulp, and small.

This variety is equally well suited for pickling or oil-making, yielding an oil abundant in quantity and of very good quality. It is a rapid grower, yielding its crops sooner than any of the other varieties. It is a regular bearer, requiring a rich loose soil. It should be pruned annually, but very slightly each time.

So far as we know there are no bearing trees of this variety in California. Though we have seen trees supposed to be of this variety in Southern California, we cannot agree with the growers as to what they are. It is beyond dispute that the true Empeltre is a *dwarf*. The trees we saw were as large as the Mission. The only analyses we have are those made in Spain.

Analysis of Empeltre.

	Spain.
Number of olives in 100 grams	20
Percentage of pit in whole fruit	20.00
Percentage of flesh in whole fruit	80.00

LECCINO, OR LECCIO.

This is a very hardy Tuscan variety that resembles the wild olive in the manner of its growth. From a distance it looks like a scrub oak (*Quercus ilex*), whence its name. It is one of the oldest varieties which we are able to recognize, being accurately described by the ancient Latin authors. Its twigs are very robust, rigid, long, and not much ramified. It resists the cold in a remarkable degree, having withstood the very low temperature of 12° (F.), which is fatal to almost all other varieties. It sets its fruit well, and never drops the crop after setting. It does especially well compared with other varieties on the coast where there are damp cold sea-winds. The fruit is almost as large and fleshy as the Grossajo, but much less rich in oil. We have no record of this variety in California, though it is grown at most of the Culture Stations.

While it is a hardy grower, and good bearer, it yields an oil that is prone to be cloudy and hard to clarify; besides being of an inferior quality as regards taste.

RAZZO, OR FRANTOJANO.

This variety is mainly cultivated in the provinces of Lucca and Pisa, together with Mignola, Morajolo, Puntarolo, and Grossajo. The twigs of the Razzo are short, light-colored, numerous, and slightly drooping.

It is the practice, in the home of this variety, to prune it less than the others, probably on account of its being a less vigorous grower. Its leaves are narrower at the insertion than at the apex; bright green on the upper surface, and has a heavy, white tomentum on the lower surface. The soils that suit it the best are those that are deep, rich, and well drained. It suffers from cold fogs and winds of the lowlands, preferring the protected hillsides. Though it is exceptionally fertile, it drops its fruit very readily, especially when exposed to winds or to

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prolonged hot spells. The fruit is roundish, fleshy, and contains more oil (in Italy) than any of the native Italian varieties, on which account it is called by the peasants "frantojani" or oil-press olive. In California, however, it does not yield so much oil as the Grossajo. The Razzo commences to ripen in November or December.

Thus far, we know of it bearing at but one place in California, "El Quito Farm," in Santa Clara County, though it is grown at all of the University Experiment Stations since quite recently.

Analysis of Razzo.

	California.
Number of olives in 100 grams	52
Percentage of pit in whole fruit	30.00
Percentage of flesh in whole fruit	70.00
Percentage of oil in flesh	33.76

THE MISSION OLIVE.

By this name is designated the variety found growing at the old Missions in California. Samples of the fruit sent to Don José de Hidalgo Tablada, a noted Spanish authority on the olive, led to the classing of our mission varieties with the Cornicabra-Cornizuelo (Synonyms: *Olea Europea Rostrata* of Clemente; *Olivo Crasiomorpha* of Gouan; *Cournaud, Corniaud, Plant de Salon, Plant de la Fane, Cayon, Plant d'Entrecasteaux, Rapunier, Olivier de Grasse, Cayonne*, etc.). However true this classification may be, it is certainly true that under the name of Mission is embraced many varieties differing slightly the one from the other; and also that by reason of the long time this variety (or varieties) has existed in California, a great change has taken place in the original characteristics, due to differences in soil and climate. This change of character in varieties of grapes brought from the same countries has been noted; and as soon as the olive industry has been as carefully studied, it will be found that there is little use in referring the Mission back to the original variety which the old Mission Fathers brought out from Europe nearly three hundred years ago. To all intents and purposes the Mission is a new variety differing from anything found in the Old World. It remains for us to pick out the various varieties of Mission and rename them without regard to European origin. This renaming is not advisable in the other cases, for the varieties are of such recent importation that there has not elapsed sufficient time for the influences of soil and climate to modify very sensibly the characteristics.

Common, or Broad-Leaved Mission.—This is the commonest form of the Mission in California. Fruit $\frac{13}{16}$ of an inch long by $\frac{10}{16}$ of an inch thick; ovate oblique—sometimes very much so—the pit straight or slightly curved, $\frac{10}{16}$ of an inch long and $\frac{5}{16}$ of an inch thick; variable in size, single or in clusters of two or more; ripens late on the coast region, sometimes not till February, but generally in December, in warmer localities in November.

Other Mission Varieties.—On the University grounds there are now being studied three apparently distinct varieties of the Mission: (*a*) *Broad-leaved* or *Common Mission*, already described; (*b*) *Narrow-leaved*

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Mission, a variety from L. A. Gould, of Auburn, described as having a somewhat larger fruit than the broad-leaved variety, and a more straggling habit; (*c*) *Early Mission*, from A. A. Wheeler. It is of the Mission type, but ripens much earlier.

Whatever be the differences, these are of the same type and are so very much mixed and confused that in this article we shall have to call them all Missions.

Analysis of Thirteen Samples of Mission.

	California.
Number of olives in 100 grams	30
Percentage of pit in whole fruit	19.60
Percentage of flesh in whole fruit	80.40
Percentage of oil in flesh	22.94

From this result it will be seen that the Mission is a good average variety. Reference to the table will show that in no locality does the oil yielded fall below 19.20 per cent, which for some of the other varieties is a good maximum; also, it will be noted that the size of the fruit is such as to render it fit either for pickling or for oil-making; while the experiments in the oil-room at the University show it to yield an oil that has better marketable qualities than most others. Its easy adaptation ought to commend it to all who are in doubt as to the special variety to be planted on new and untried soils. Careful comparative observation shows that it really is no more irregular than the other varieties. There are more localities where it has proved to be irregular, because there are at least ten localities where Missions are grown to one where other varieties grow.

REDDING PICHOLINE.

This was imported from France by the late B. B. Redding. It was imported for the large pickling olive known in France as Picholine, and very highly esteemed there for that purpose, as well for the small quantity of high-grade oil it yielded. For a long time it was supposed that the Redding Picholine was after all the true Picholine of Europe. Reference to the description of the true Picholine will show that this is an error. To-day the Redding Picholine is very widely planted in California, and, by many, is highly esteemed on account of its abundant crops and very vigorous growth. While it yields oil abundantly, the latter is of an inferior quality on account of the extreme difficulty of maintaining it clear and brilliant. The oil-room experiments showed it to be the most difficult in this respect. It solidifies very easily and is hard to clarify. From samples of Redding Picholine oil as seen at the Columbian World's Fair in Chicago and also at the California Midwinter Fair, these observations were proved to be correct; the oil being prone to deposit a white granular, "lardy" sediment after a short time.

FRUIT is perfectly oval in shape, $\frac{5}{16}$ of an inch long and $\frac{4}{16}$ of an inch thick; ripens early, several weeks sooner than the Mission; is dark purple or black in color; in pickling the pulp loses its bitterness quickly, the fruit being pleasant to the taste.

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Analysis of Six Samples of Redding Picholine.

	California.
Number of olives in 100 grams	79
Per cent of pit in whole fruit	24.42
Per cent of flesh in whole fruit	75.58
Percentage of oil in flesh	24.65

From this, taken with the complete analysis in the large table given below, it will be seen that the exceptionally small size of the fruit and the very high percentage of pit in the whole fruit makes it a variety not at all adapted to pickling, while the oil-room experiments show it to be a very poor oil variety. The reason that it gained such a foothold in the plantations of this State seems to be that it was supposed to be the true Picholine of Europe, a variety held there in high esteem. It was planted very extensively before the true nature of the variety was discovered. With all its defects it is an abundant bearer, and is very vigorous, hence very well adapted as a stock for grafting the more feeble varieties.

Several oil-makers have, after careful experiment, decided to mix no more Redding Picholine oil with that of other varieties, for the reason that they consider that the keeping and marketing qualities of the mixture is injured by so doing.

It has been noted that the quality of oil made from this variety is much better on gravelly hillsides than on richer bottom land. On a rich soil the oil yielded is especially bad, not only as regards keeping qualities, but in taste also.

While the present limited supply of pure California oil enables that made from this variety to find a ready market, growers must remember that this state of affairs will soon change and only the best will be called for. The tree is such an excellent grafting stock that it can be readily grafted into just as prolific varieties which do not have the same faults.

For those intending to change the variety, we recommend trying the combination graft and bud. Use a regular grafting scion inserted in the usual way practiced in budding. This has been found by some nurserymen to be better than grafting proper, or the usual method of budding.

RUBRA.

SYNONYM: *Caillon (?).*

This was imported from France by John Rock, of Niles. It is somewhat like the Mission in general appearance; *fruit* ovate, slightly oblique, smaller than the Mission, $\frac{2}{16}$ of an inch long, $\frac{8}{16}$ of an inch thick; *pit* straight, pointed, $\frac{8}{16}$ of an inch long and $\frac{4}{16}$ of an inch thick; *maturity* early, ripening from three weeks to one month earlier than the Mission; jet-black in color when allowed to hang on the tree. The tree begins to bear early and is quite prolific.

Analysis (average) of Nine Samples of Rubra.

	California.
Number of olives in 100 grams	40
Percentage of pit in whole fruit	17.80
Percentage of flesh in whole fruit	79.94
Percentage of oil in flesh	22.95

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By reference to the general table it will be seen that the Rubra is, when well adapted to soil and climate, an excellent variety for oil, as it yields as high as 34 per cent in some cases, and of superior quality. The chief defect of this variety seems to be that it is more variable than any of the other varieties tried at the University Experiment Station, the variation between maximum and minimum being as high as 20 per cent in oil contents. It seems to do badly in low rich bottom land, and best in poorer soil. At Newcastle, where the highest percentage was reached, the soil is of granitic formation, not at all rich, but high, and well drained.

There seem to be several varieties called Rubra in this State. We have not been able to identify it with any well-known European variety on this account.

REGALIS.

This was imported from France by John Rock, and is quite extensively known in California. *Form* almost perfectly round, oval, dark purple or black; large, $1\frac{1}{16}$ inch long by $\frac{13}{16}$ of an inch in thickness; *flesh* firm; *pit* $\frac{9}{16}$ of an inch in length by $\frac{5}{16}$ of an inch in thickness, generally straight, square at the base, pointed at the apex; ripens slightly ahead of the broad-leaved Mission variety.

Analysis of One Sample of Regalis.

	California.
Number of olives in 100 grams	34
Percentage of pit in whole fruit	22.00
Percentage of flesh in whole fruit	78.00
Percentage of oil in flesh	21.60

We regret that no more samples were obtainable for analysis at the Station, as this variety is very highly spoken of by many; but it would be unwise to judge of it from but one analysis. We do not know what the European name of this variety is, as great confusion is noted. All those who are able are requested to furnish the Station with what data they can.

COLUMBELLA.

This was imported from France by John Rock, of Niles. General *form* broadly oval, $\frac{14}{16}$ of an inch long and $\frac{11}{16}$ of an inch thick; very even in size, remarkable for the peculiar pale-yellow color the fruit assumes before turning purple; *pit* small, $\frac{8}{16}$ of an inch long and $\frac{5}{16}$ of an inch in thickness, straight and sharp-pointed; the *pulp* seems to part with its bitterness slowly, but when properly prepared it has a delicious flavor. It ripens late, some time after the broad-leaved Mission.

Analysis (average) of Five Samples of Columbella.

	California.
Number of olives in 100 grams	41
Percentage of pit in whole fruit	18.00
Percentage of flesh in whole fruit	82.00
Percentage of oil in flesh	18.77

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From these analyses it will be seen that the Columbella is not very rich in oil, though the quality of its oil is very good. We have been unable to find out under what name this variety is grown in Europe. It is sometimes called Columella, but Columbella seems to be the most popular name.

OBLONGA.

This was imported from France by John Rock, of Niles, Alameda County. It is an olive of peculiar club-like shape, being narrow at the stem end, broad at the end, rounded, and strongly oblique, $\frac{1}{16}$ of an inch long and $\frac{8}{16}$ of an inch thick. *Pit* is curved, $\frac{1}{16}$ of an inch long by $\frac{4}{16}$ of an inch thick, and generally pointed at both ends. The *pulp* loses its bitterness comparatively quickly in pickling, and is very pleasant tasting, which recommends it especially as a pickling variety. It ripens at least two weeks earlier than the common broad-leaved Mission. *Color*, dark purple.

It is commonly supposed that the Oblonga is the same as the true Picholine of Europe. There seems to be little foundation for this belief, as the two varieties are quite distinct. We are uncertain as to the true name of this variety.

Analysis (average) of Six Samples of Oblonga.

	California.
Number of olives in 100 grams	40
Percentage of pit in whole fruit	19.00
Percentage of flesh in whole fruit	81.00
Percentage of oil in flesh	17.02

From this it will be seen that the Oblonga is not one of the best varieties for oil-making, although the quality of its oil is very good. The delicate flavor of its flesh renders it adapted for pickling; although the percentage of pit in the whole fruit is not especially small, yet it is not too great, and the size of the olive is fair. One of its peculiarities seems to be that the quantity of flesh diminishes very much during the process of pickling, so that when pickled the percentage of pit in the whole fruit seems to be much greater than the table would indicate.

LIST OF OLIVE VARIETIES PLANTED AT THE STATIONS.

There are at present planted at the five Experiment Stations of the University of California the following varieties:

1. Amellau.
2. Ascolano No. 1.
3. Ascolano No. 2.
4. Ascoli.
5. Atrorubens.
6. Atroviolacea.
7. Bella de Spagna.
8. Belmonte.
9. Cayon or Rouget.
10. Champion.
11. Columella.
12. Corregiola.
13. Cucca or Cucce.
14. Dalmatian.
15. Empeltre.
16. Frantoio or Frantojano.
17. Grossaia (Grossajo?)
18. Grossayo (Grossajo?)
19. Gentile.
20. Hervaza.
21. Hispania.
22. Huff's Spanish.
23. Infrantojo.
24. Lavagnino.
25. Leccino.
26. Lucques.
27. Macrocarpa.
28. Mission, Nos. 1, 2, 3, and 4.
29. Mignollo.
30. Morchaia.
31. Morinello.
32. Nevadillo Blanco.
33. Nigerina.
34. Obliza.
35. Oblonga.
36. Olivastro.
37. Oriola.
38. Palazzriolo.
39. Pendulina.
40. Pendoulier.
41. Piangente.
42. Picholine.
43. Pleureur.
44. Polymorpha.
45. Praecox.
46. Razzo.
47. Redding Picholine.
48. Regalis.
49. Rosselina.
50. Rubra.
51. Ruffa.
52. Salonica.
53. Santa Catherina.
54. Uvaria.
55. Verdale.
56. Becca Ruffa.

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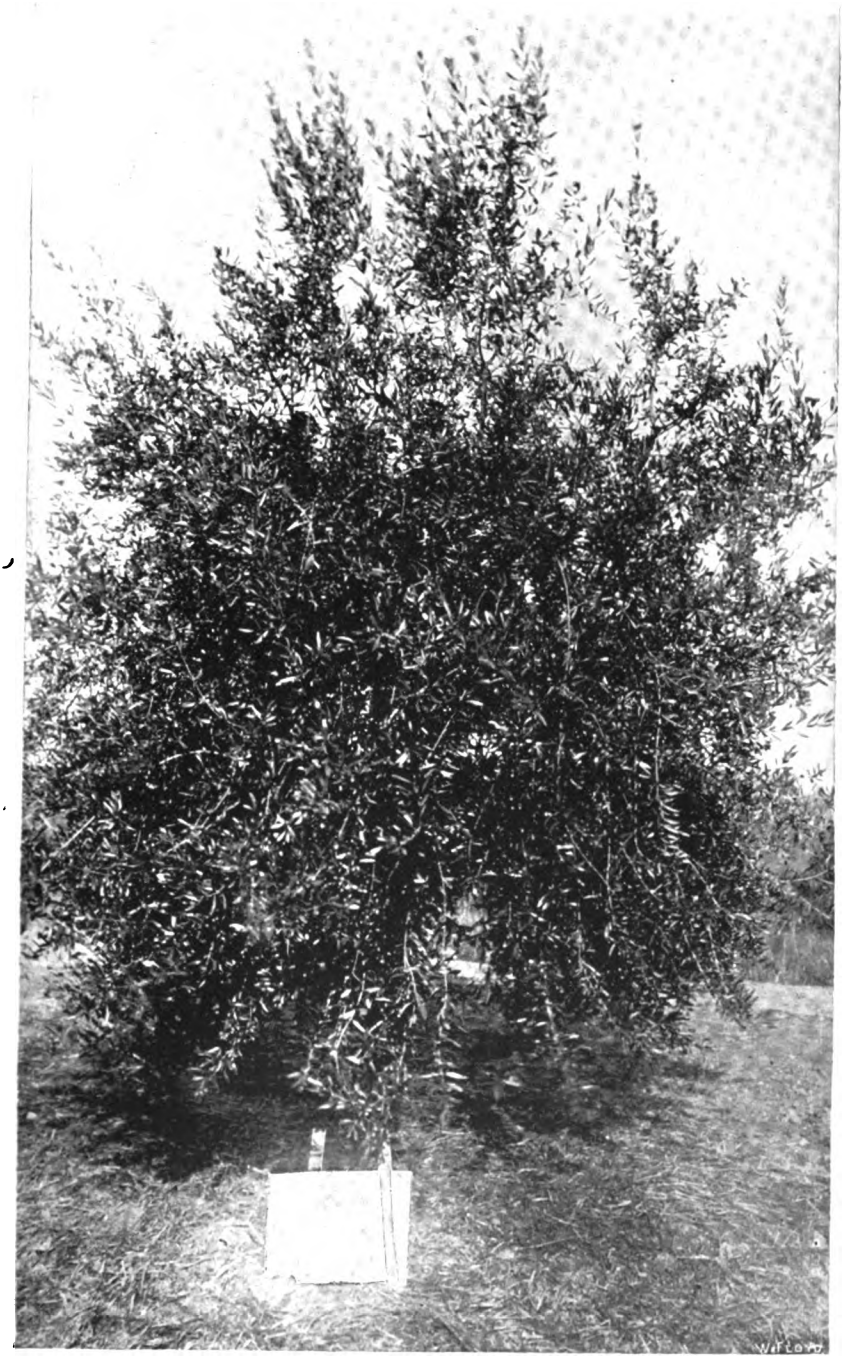

TREE OF THE OBLONGA OLIVE, 10 years old.

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While we have attempted to describe only those varieties of which there are descriptions extant, we purpose to continue this work of classification and description till all on this list have been thoroughly studied. It is hoped that any one having any data (information as to importation, samples of fruit, etc.) will take the earliest possible opportunity to communicate with the Agricultural Experiment Station at Berkeley, so that this work may not be delayed. It is only by such methods that we can ever hope to gather all information desired.

A NEW DISEASE OF THE OLIVE TREE.

My attention has been called to a new disease affecting the leaves of the olives, in various parts of the State. After careful microscopic examination I have, I think, identified it as a fungus described in Europe as *Cycloconium oleaginum*. This fungus was first described by Castagne, later by von Thümen and others; more recently and completely it has been studied by Monsieur G. Boyer, of l'Ecole Nationale d'Agriculture de Montpellier, France. It is from his valuable study that I make the following brief observations:

Up to the present time it was commonly conceded that this fungus existed only on the olives of France; its presence having been noted only on the olives in that country. It lives on the two faces of the leaf, though sometimes found on the peduncle and fruit also. On the upper surface of the leaf, where it is most commonly found, it forms circular spots, frequently blackish in color, sometimes gray or brown, the centers of which usually are of a different color from the surrounding surfaces of the circle. The majority of these discolored spots are from six to ten millimeters in diameter, though on large-leaved varieties they may be fifteen and more millimeters in diameter. The spots are irregularly distributed over the blade of the leaf, in numbers varying with the intensity of the disease. The *Cycloconium oleaginum* appears on the leaves at all seasons of the year; even on the same leaf one sometimes finds it in all stages of development. It usually, however, makes its appearance at the end of summer or in autumn. The color of the spots is usually blackish at first, fading to brown or gray, the rest of the leaf becoming quite pale-green or yellow, thus defining them quite well from the unaffected parts of the leaf. Von Thümen compared them to the spots or "eyes on the feathers of a peacock's tail."

Monsieur Boyer was the first person to note the presence of the fungus on the peduncle and fruit. He noted that in this location the fungus produces isolated or confluent spots that preserve a uniformly blackish color throughout their existence. The narrow spots are on the median nerve of the leaf, usually covering its entire length. Young or partly developed leaves never show the spots, only fully grown leaves being attacked. Microscopic examination shows that this blackish coloration of the affected parts is due to the presence of innumerable black spores. As these become fully developed and blow away, the color becomes lighter, as previously noted.

The reason the disease is not found on the branches is because the epidermis scales off during the second year and the fungus cannot penetrate the layer of cork that covers the bark.

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The fungus sometimes develops on the leaves of the olive quite abundantly, rarely on the fruit. It seems to prefer certain varieties, such as the Lucques, Amellau, Rouget, and Verdale. In California I have found it only on the Mission, but thus far I have been unable to make extended search for it. As its development on the fruit is very late, there is nothing whatever to fear in this regard. On the leaves its development is so very slight, and the damage caused is so insignificant, that it is a disease not likely ever to become of sufficient importance as to require treatment of any sort. The only reason for mentioning it in this place is that many have noted its presence and were fearful lest it might be some new and dangerous disease; which is not the case.

OLIVE CULTURE.

Perhaps one of the reasons that the olive seems more vigorous in California than the same variety in Europe is that here we have no "mixed crops" of olives, grain, potatoes, etc., and that we plant the olive on the best soil we have, instead of on the poorest. It is certainly true that in California the olive is a more vigorous and prolific tree than in the Old World. Not only do the trees attain larger dimensions, but the yield of oil and fruit is greater for trees of the same age than elsewhere. While it is certainly true that the olive will live and bear fruit on a very poor soil, it is incontestable that the tree thrives better and prefers a rich soil. By rich soil we must not understand black adobe bottom, or rich marshy bog land, but rather any loose, well-drained land, containing all the elements necessary for the proper nourishment of the tree. That it is found on the poorest kind of land in Europe is no proof that it prefers such; but merely goes to show that the olive tree is remarkably patient and long-suffering.

Personal observation in Europe and Africa has convinced me that, in California, the crops are larger, other things being equal, than in Europe; while analyses made at the University prove that as a rule the percentage of oil contained in the flesh of the fruit is greater than that shown by foreign chemists for continental olives.

CARE OF THE OLIVE TREE.

It is an error to suppose that the olive is by nature more irregular in its crops than any other fruit tree. If let alone, on the contrary, it would seem to be more regular. The apparent irregularity seems to us to be due to a neglect of the usual care in the cultivation, and not all to any inherent tendency to be irregular. The most important thing in olive culture, as in the case of that of all fruits, is the retention of the moisture in the soil, by proper plowing, cultivation, etc.

Pruning.—Of all the operations in olive culture, after the cultivation of the soil, that of pruning is the most important. The influence of the operation is incontestable; for intelligent pruning regulates the production of fruit and improves its quality. The drupes are larger, the crop is more abundant and more regular when the nutritive elements in the sap have been properly fostered and turned to the profit of the tree in fructification.

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But while this is accepted by all intelligent olive-growers, there are many who, relying on tradition and abnormal conditions found elsewhere, practice most remarkable systems, in some cases most injurious to the tree. In order to understand the importance of the operation, and the principles that should guide us, let us consider what the olive tree is, and what are its leading characteristics.

"The olive belongs to the family of *Oleaceæ*, which have persistent leaves, and which bear fruit with pits; *it bears its fruit on the wood of the preceding year, and never twice on the same wood.* It throws out adventitious shoots very readily, and suckers abundantly. Finally, it can, by rational pruning, be made to yield regular, abundant, and early crops." Such is the definition of the olive tree as given by M. F. Gos, Director of the National School of Agriculture at Antibes, France. If we keep this definition always in mind we have the true guide for pruning the olive.

In the case of a young plantation the first important object is to give the tree a strong, vigorous start, to prepare it for subsequent treatments. One of the commonest practices seems to be to cut away all the lower shoots on the trunk of the tree as soon as they appear at the end of the first year. In consequence, we find that the growth is checked, the tree grows very little the following year, and gets so top-heavy as to require a stout stake to keep it from falling to the ground. The best method would seem to be to allow the young tree to grow as it will the first year, and the following spring to trim off the *ends* of all the lower shoots below the point where it is desired to have the tree "head out."

The fact that the growth of the roots is in direct ratio to the foliage, should not be lost sight of. When the tree is transplanted, the roots have been cut away to such an extent that its life is in danger; and all efforts should be directed to giving the young tree as vigorous a root growth as possible before any attention is paid to the ultimate shape of the tree. I have seen many plantations retarded for several years by too great haste in "shaping the tree." Once the young olive has a vigorous root growth, it will support the severest kind of pruning, but it will be stunted if "shaped" too soon.

At the end of the second year, all the lower shoots can be cut away without endangering the growth and development of the trunk. It should be observed that in cutting away a branch, care should be taken not to cut too close to the main stem. Though not so neat, it is better to leave a spur a half of an inch long, even at the risk of having a crop of young growth start around the spur, to be cut away at some other time. Cutting too close to the main stem is a fertile source of feeble, diseased trunks, and consequently of small crops of small fruit when the tree has reached full growth.

Having, then, a young tree at the end of the second year, with no shape at all, and a mass of shoots of various lengths all over the tree, we must decide at what height the tree should branch. Some are in favor of having olive trees branch out five or six feet from the ground, and training them afterwards like forest trees. Others prefer the low, spreading, "bush-like" form. It is claimed for the high-branching plantation that it is easier to cultivate close to the trees and that the ultimate fruit-bearing surface is vastly increased, while the danger from insect and fungous diseases is greatly lessened. It is claimed for the low-growing plantation that it is easier

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to prune the tree, and that there is less danger from sun-burn on the trunk; while the ground can be cultivated with as much ease as in the case of high pruning. However this may be, it is certainly true that there is danger of severe sun-burn in hot climates; I have seen hundreds of beautiful trees very much injured from it where the trunk was not protected.

Low-pruning renders the harvest much less expensive, and facilitates access to all parts of the tree. So far as regards diseases, it would seem that, since the introduction of the Australian ladybirds, it is better to prune low, if for no other reason than to furnish these friendly insects with a good breeding-place. Mr. Ellwood Cooper, of Santa Barbara, has after almost twenty years of experience, abandoned the high pruning for the low.

In localities subject to frost, it is best to prune the tree as high as possible, in order to escape frost-bitten fruit in case of an early frost. In California, with its very fertile soil, the olive tends to run to wood, and pruning too high would seem to cause a loss of force that might be given to the fruit instead of to the branches. One of the evils of high-growing trees is most strikingly seen in the neighborhood of Nice, where the trees are as large as oaks. Not only is harvesting very expensive, but the yield per acre is less than where the growth is kept within proper limits. It has been found that "low pruning" in the case of spreading trees, such as the apricot, peach, etc., does not give any more trouble in cultivation than the system of high pruning, and at the same time renders the harvesting much easier and cheaper. Hence, we find that the tendency now is to a far lower system of pruning than heretofore. In the case of the olive, we should not forget that, with very few exceptions, it bears most of its crop on the lower branches. Some varieties, in fact, never bear fruit on the upper branches. We therefore feel that we should be in favor of low pruning, other things being equal.

Having then decided to favor low pruning, what form should be given to the tree? The simplest, the most easy to obtain, and the easiest to maintain, is without doubt, the "goblet" form. It is well adapted to the most feeble as well as to the most vigorous varieties, and at the same time brings all parts of the tree into free communication with the air and light, besides facilitating pruning and harvesting. In our climate and soil, the olive is very vigorous, and tends, if let alone, to run to wood; hence care should be taken, from the start, to train the tree in goblet form so as to maintain it in good proportions.

The practice of trimming off at each pruning the twigs at the base of the branches, cannot be too strongly condemned. It is the branches at the base, especially those that fall toward the ground, that bear most abundantly, when given sufficient room for development, with proper amount of air and light. The heaviest crops are obtained from well-pruned trees, so even where labor is as expensive as in California it would seem to be economical to prune regularly. It must not be lost sight of that the action of light is an important factor in the formation of the oil in the fruit. Besides this process resulting from the direct action of the sun's rays, there is another equally important result on the coast of California, viz.: The check to fungous diseases, which never develop so well on well-aired and well-lighted trees.

Among fruit trees and shrubs, some (such as the grapevine) bear their fruit only on the wood of one year; while others (such as the pear,

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the apple, etc.) only bear on old wood. Between these two types there is another of which the olive and the peach are the best known examples, which bear only on the wood of the second year. In this latter case a twig starts one year and is capable of producing fruit the following; but the part that has once produced fruit will never again bear. However, the shoot will grow longer, and *on the prolongation* there will be a succession of crops for a *limited number of years*, when the fruit-bearing branch will become feeble and finally die. If removed in time, it will be replaced by a new fruit-bearing twig at the base of the old one. A peach tree, pruned in this manner, has been made to produce regular crops for over a century. The most wonderful results have been obtained in the case of the peach, which is a more difficult tree to handle than the olive, for the reason that it is more difficult to make a peach tree shoot out new fruit branches to replace the old ones, than in the case of the olive. Otherwise, the mode of vegetation is exactly the same.

We should never lose sight of the principle that *the olive never blossoms on other than wood two years old*, and that it produces adventitious shoots with the greatest ease. After having applied the general principles of pruning (short pruning; suppression of foliage on the strongest side; long pruning and trimming toward the vertical on the less vigorous side in order to maintain the equilibrium and shape; after having suppressed the woody branches and suckers, and having insured free circulation of air and light throughout the center of the tree) it is not necessary to have recourse to any severe system of pruning. The pruning of the olive, then, consists in simply cutting away the feeble fruit branches that have produced fruit for several years in succession.

Time to Prune the Olive.—Immediately after the harvest is the best time to prune the olive; for then the tree sends out a new set of fruit-bearing twigs. During the following spring all suckers should be suppressed, and all vertical suckers should be cut off.

Should the Olive be Pruned Frequently?—Here we are in the presence of many systems, all of which have warm advocates. In the most progressive olive-growing regions of Europe annual pruning is practiced. This results in annual crops. Each year, after having gathered the crop *by hand* and NOT by *beating off the fruit with sticks*, all branches that have borne fruit are pinched. This causes the formation of new fruit-bearing twigs for the following year; at the same time it does not interfere with the maturing of a good crop. In spite of the high wages paid in California it would seem economical to prune annually and have regular crops instead of every two years, as in Europe, and have irregular crops.

Certain varieties, such as the Mission, have a tendency to send out a number of very long vertical branches. If these be not regularly "topped" the tree soon becomes top-heavy, besides rendering the harvesting of that part of the crop almost impossible.

FROZEN OLIVES.

There are few parts of the olive-growing regions of the world where an exceptional season or an early frost does not sometimes surprise the grower before the harvest is completed. The fruit of the olive is much more sensitive to the effects of cold than the tree itself. Hence, in localities thus subject to early frosts, care should be taken to plant only those

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varieties that mature early, for once an olive has been frost-bitten, it is next to impossible to make a salable oil out of it, and it is quite impossible to make a pickle that can be eaten. The water in the juice of the olive freezes, and in so doing expands, tearing the tissues of the flesh. This in itself, of course, would not injure the quantity or quality of the oil in any way, but unless the frost-bitten drupe is at once crushed and the oil expressed, the broken tissue decomposes and imparts to the oil a most disagreeable taste and odor, rendering it unfit for the table.

Among the samples of olives received at the Station this year were several that had been frost-bitten, either before picking or while awaiting shipment. These were separately made into oil as soon as possible. It was found that a delay of three days from the time the olives were frozen to the time of crushing and pressing, was fatal. The oil was, to the eye, as clear, and to all external appearances as good, as that made from unfrozen olives, but the taste was such as to render it unfit for use. The odor was very disagreeable and very pronounced, and those who tasted the oil pronounced it "made from fermented olives."

When we consider that a delay of three days in crushing caused this, we can at once realize the importance of early harvesting, and therefore, of the selection of early maturing varieties to escape frost, for on a large scale it would practically be impossible to express the oil any sooner than three days.

This fact accentuates the importance also, of picking the fruit as soon as it reaches true maturity, instead of leaving it on the trees any longer than is absolutely necessary.

From the University Experiment Stations it was learned that the Nevadillo Blanco was the first to be frost-bitten, the Nigerina second, and the Pendulina third. This being an exceptionally severe season, it was found that at the four Stations where there were olive trees in bearing, all of the varieties were frozen before the first of January.

It would be well for oil-makers who buy the crops of local growers to look carefully to this, as I know of many having been deceived. It is far better to have the crop harvested early, evaporated, and well stored, than to let the fruit hang on the trees till the grower "has time" to pick them, risking the ruin not only of all the frozen fruit, but of all oil that is mixed with this product.

MATURITY.

This is a more important subject than is generally supposed. Indeed, the common ideas concerning the proper state at which the olive should be picked, either for pickles or for oil, are for the most part wrong, being based on false premises concerning the chemistry and physiology of the olive. It is regarded as fundamental that an olive is not ready to be harvested before it is jet-black, and that it makes no difference how long it hangs on the tree after this jet-blackness has been reached. The old European myth that the longer the olive remains on the tree after it begins to color, the more oil is formed in it, seems to be accepted even in such a progressive country as California.

The actual quantity of oil in an olive is the same the day it first reaches redness, as two months after jet-blackness has been reached, tradition to the contrary notwithstanding.

The change that takes place in the composition of the olive oil itself by

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such waiting, is marked, and bad for the quality of the oil. Other things being equal, the longer an olive remains unpicked after true maturity has been reached, the greater the amount of palmitic and stearic acids formed at the expense of the olein, or that which gives the true quality to olive oil. This change in the proportion of the constituents of the oil causes it to become "greasy" to the taste, and more apt to solidify or deposit a white granular sediment in the bottles. On the European market such "greasy" oils do not command the same prices as those that have not this characteristic. The difference in price is sufficient to make it worth the while to remedy the defect by more prompt harvesting.

But aside from this loss of quality, there is considerable loss caused by the olives falling to the ground when "dead ripe," also loss from birds and the larvæ of certain flies, such as the *Dacus oleæ*, which in Europe sometimes cause the loss of the greater part of the crop.

HARVESTING.

The most common method of removing the olive crop from the trees in Europe is by means of poles. The ground underneath the tree may or may not be covered with a cloth, and the fruit is beaten off, and afterwards gathered up into any sort of receptacle. This custom cannot be too severely condemned, as well as that of using "combs" or rakes, as is done in some parts of California. The olives are so bruised that it is impossible to keep them any length of time, however short, without their moulding and becoming unfit for the manufacture of any but the most inferior grades of oil. The trees are scratched and torn to serious extent; the young and tender shoots are knocked off, and the olives get so mixed with leaves, etc., that the separation is rendered impossible, besides the irreparable injury to the fruit-bearing wood for the following crop. Where the highest grades of oil are made only hand-picking is allowed, great care being taken to avoid gathering the leaves, etc., at the same time. In California only hand-picking is commonly employed by rational oil-makers. On large plantations, such as those in Santa Barbara and elsewhere, where the trees are trained high, it is customary either to drive a wagon, on which are small step-ladders, under the tree, and thus do away with the necessity of handling large, unwieldy ladders, or to use "patent pickers"—which are nothing more than easily-moved ladders on wheels. The workmen use either buckets, baskets, or canvas bags, so attached to the body of the picker as to enable him to use both hands at once. This greatly facilitates the operation, and at the same time does not bruise the olives so much as the direct picking into a hard bucket or basket.

For pickles the greatest care is necessary. The slightest bruise in the fruit will detract from the value of the pickle, be it preserved ever so carefully. In some parts of Europe and California it is customary to pick the olives destined to be pickled into buckets half filled with water, so great importance is attached to keeping the fruit sound and free from bruises. From this it will be seen that the essential point in harvesting the olive crop, whether for pickles or for oil, is to avoid all bruises.

It is also necessary to finish the harvest as soon after it has been commenced as possible. We have shown how very important it is that the olive should be picked at proper maturity, and not be allowed to get

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overripe. Practically, on a large scale, it is difficult to harvest the crop with sufficient rapidity to keep pace with the maturing of the fruit. No doubt it is true that it costs no more to hire a hundred men for one day than one man for a hundred days, but it is not always possible to do so. It is possible, however, to make due preparation in advance, and to have the work done as rapidly as possible, knowing that the quality of the oil will deteriorate much less if the fruit is picked and well stored than if allowed to hang on the tree. Besides, it is far easier to keep the olives from moulding and acquiring bad tastes when they are picked before jet-blackness has been reached.

The expense of harvesting is greatly lessened by the low pruning of the trees. Aside from obtaining a larger crop from low-pruned trees, and the reduced cost of harvesting, it is much easier to carefully handle the olives and avoid bruising when the fruit to be picked is within easy reach of the workman, and the distance between the workman on the tree and the main receptacle into which he empties his basket, etc., is small.

As soon as the olives have been picked, the workman should empty his "apron" or basket into *boxes*. The custom of putting the olives into sacks or very large bins cannot be too strongly condemned. No amount of careful sorting can ever make up for the damage thus done the crop. The boxes used to bring the crop from the orchard to the mill should, in no case, be charged with more than 75 pounds of olives. The oil-maker who permits the handling of the olives he uses for first-grade oil, in anything else than small-sized boxes, will soon lose his reputation. There are many illustrations of this in our own State. Here it would be well to call attention to the fact that the evaporation of the olives before crushing is merely to get rid of an excess of moisture that would otherwise favor the rapid moulding and fermentation of the fruit. It is a common idea among oil-makers, that the quality of the oil is, in some mysterious way, benefited by the evaporation of the olives as soon as they come from the field. The only good it does is to *prevent* moulding or fermentation, otherwise it is an expense that should be avoided, if possible, by crushing the crop at once.

If the olives are poured into sacks in the orchard and loaded on wagons, as is done in many places, and thence carried over rough roads to the railroad, re-shipped many times till they reach the mill, and then evaporated, the oil made from them will be about equal to a fourth-grade oil made in the usual way. I mention this because I know that it is being done, and I have been asked why the oil had a "peculiar earthy taste." There is but one way to avoid this, namely, by pouring the olives from one receptacle into another as seldom as possible, and then taking all precaution not to let them fall from too great a height. The custom of letting the fruit remain even for a short time in piles or masses of any considerable height cannot be too carefully avoided. An olive that has been bruised and allowed to remain in still, warm air will become mouldy within twenty-four hours. Once it is mouldy, the evil has secured a place in the fruit and whether it be evaporated or not, the mould is still there, awaiting only favorable circumstances to continue its development, either before the fruit has been crushed or after the whole has been pressed. Moulds do not develop on the *dry* surface of unbruised olives; they require a certain amount of *moisture*, usually supplied by the juice of the bruised olive, or even when it has not been

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bruised, if the evaporated water cannot at once be carried off from the surface of a perfectly sound fruit, there is ample moisture supplied to start the mould germs. This is usually the case when sound olives are kept in layers of more than three inches in thickness without a current of dry air in free circulation on all sides of the fruit. The free circulation of air is essential, for even though the crop be evaporated and stored in large heaps, without free circulation, there is always sufficient moisture to cause the germs to sprout, thereby causing the fruit to mould.

Of course bruised olives are the most apt to develop fungi; in fact, it is next to impossible to prevent badly bruised fruit from moulding. The bruising of an olive means that all the cells of the injured part are killed, and that the mycelium of the fungus can have unlimited nutritive media for its development. The bruising simply kills the vitality of the cells and gives full swing to the unhindered development of fungi. When an olive is so badly moulded that the mould can be seen with the naked eye, it is in the last stage of decomposition. It must be remembered that the fungi that cause olives to "mould" are essentially microscopic, and it is only when a countless growth is present that they can be detected by the naked eye. Hence, too great care cannot be taken to prevent the slightest growth of fungi. Just so surely as there is no free circulation of air, so surely will there be mould, to a greater or less degree, even though the olives be not bruised.

STORING THE FRUIT.

It is a matter of great importance to have the oil-mill sufficiently large to crush the olives as soon as they are picked. Unfortunately, owing to the necessary expensive machinery, few can afford to have their oil-mills on a scale that will permit of this. Hence, it is necessary to store the fruit in such a way that as little deterioration as possible takes place. There are two ways practiced in California. One is the European method of storing the fresh olives in shallow trays with loose bottoms, so that the air can circulate freely. The other is to evaporate part of the water of vegetation by artificial means, and then to store in shallow trays. In hot dry climates, such as are found in the interior of the State, the San Joaquin Valley, etc., artificial heat is not necessary for the evaporation of the fruit. But along the coast, where damp fogs sometimes prevail for weeks at a time, artificial heat becomes more important. Though the use of artificial heat is not as good as the non-application of it, yet it is practically better to put up with the damage done by artificial or forced evaporation, rather than incur the risk of far greater damage resulting from the moulding of the fruit consequent to the storage of unevaporated olives in moist climates such as are found on the coast. Nothing takes away so much of the quality of olive oil as a slight mouldy taste, which can be imparted by a few decomposed olives. When an oil has once acquired this taste, *there is no way of getting rid of it.*

As soon as the olives are picked, they should be at once taken to the oil-mill and if not crushed at once, or within a couple of days, they should be dried in shallow trays similar to those used in the drying of peaches, apricots, etc. Great care should be taken to avoid over-heating, which is fatal to the quality of the oil. On no account should the temperature be allowed to pass 110° F. Even when evaporated to one third

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the original weight, the olives should not be stored in layers more than three inches thick in the trays.

CLEANING THE CROP BEFORE CRUSHING.

However carefully the olives are picked, there will always be a considerable admixture of leaves, clods, and foreign substances in the crop as it comes from the orchard to the mill. Careful oil-makers attempt to clean the fruit before crushing. Some employ children to pick out the impurities by hand, others attempt to remove the lighter impurities by winnowing, either by an ordinary fan-mill or by letting the olives fall through a current of air; others again use water. Of all these methods the water seems the best; for the winnowing, either by hand or machinery, will only remove the lighter impurities and has the disadvantage of bruising the berries. A properly arranged water-trough enables the crop to be handled far quicker, without bruising; and at the same time removes all soluble matters, and the very fine dust which adheres to the skin too strongly to be removed by the action of air. Olives grown along the roadside or in a dusty locality are sometimes so covered with dust that it is almost impossible to see the natural color. All this is removed by good washing, and the ease and rapidity with which the crop can be handled gives to the water method a great advantage. The olives, being stored in the loft above the oil-mill, are made to fall down a large pipe into a large trough with perforated bottom, so arranged that by a single movement the auger holes in the bottom may be opened or closed by a lever or slide. The water supply should be so regulated that the trough can be filled almost instantly. One end of the trough should be fitted with a slide so that after washing the berries and skimming off the leaves, the whole could be opened and allowed to run into a bucket with perforated bottom, standing over an escape pipe. In this way a great saving of time can be effected in the handling of the olives, besides the advantage of crushing only clean fruit.

It is frequently said that olives should not be wet before crushing, on account of the supposed bad effect of the water, either upon the oil or in other ways not clearly described. This is a mistake. Water alone, without heat, can do no harm whatever. In case the olives have been over-dried it is the custom in many of the best oil-mills to add enough to supply the deficiency, and thus render the crushing and expression of the oil easier. It is certainly true that hot water has invariably a bad effect on the oil. It is said by many of the experts of Europe that the quality of olive oil varies inversely as the temperature of the water used. All oil made with the application of water heated above the normal temperature of the air is rendered inferior, fit only to be used for burning or lubrication.

There is no inconsiderable saving in the quantity of oil by the moistening of the skins of the evaporated olives with water; for otherwise just so much oil would be used up in merely wetting the skins of the fruit, and no amount of force can ever render this available.

CLEANLINESS IN OLIVE OIL-MAKING.

Too great stress cannot be laid on cleanliness, the want of which may, without any exaggeration, be said to be the most fertile source of inferior oil. It is useless to have an expensive, modern oil-mill, if scrupulous

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care be not taken to keep not only the machinery itself, but the building and everything near it perfectly clean. The mill-stones and crushing-trough, etc., should be well washed with hot water at least once every day, even when the mill works day and night without interruption. It is the common belief that the mill-stones need not be washed so long as the mill is kept constantly at work. This is an error; for the splashing of the juice heavily charged with vegetable matter and oil will in a short time cause it to become befouled with one of the most fertile materials for the breeding of endless fungi, which scatter their spores everywhere and impart a bad taste to what might have been, otherwise, perfect oil. The floors of the buildings soon become spattered with oil and covered with scraps of skin, flesh, etc. Constant sweeping will not serve to correct the evil; only scalding water freely applied will keep everything properly clean and sweet-smelling. The oil as soon as it is separated from the juice should be at once removed from the immediate neighborhood of the oil press, and kept carefully guarded from every odor.

Above all, smoking should not be tolerated. Not merely smoking in the neighborhood of the oil-mill itself, but the workmen should not be allowed to smoke at all, even when not on duty. *All smells, of whatever nature*, should be kept away. At the end of each season, or just before the beginning of a new campaign, the walls of the building, etc., should be given a generous coat of whitewash. Every speck of rust should be carefully banished from all possible contact with olives, juice, or oil. All smoke should be excluded; for olive oil will acquire a "smoky" taste if a wood fire be permitted anywhere near the premises.

THE OIL-MILL.

The oil exists in the olive in a finely emulsified state in the juice, which is equally distributed throughout the drupe. In order to express this oil-containing juice, it is necessary to crush the flesh in such a way as to break the tissues and allow free egress to juice and oil. Practically this operation has always been done by means of large mill-stones revolving in a trough-like path, crushing to fine paste the pit as well as the pulp of the olive. This is not the best way theoretically, but the simplest thus far practically. The kernel of the olive pit imparts a bad taste to the oil, besides introducing certain oils that cause the oil of the flesh, or the true olive oil, to become rancid much sooner than if the pit were not broken. It is not necessary to remove the pit from the mass of flesh before pressing, indeed it is better to leave the pits to stiffen the paste and thus render it more easily handled. All that should be, if possible, avoided, is the breaking of the pit and the consequent mixing of the flesh-oil with the kernel-oil. It is asserted that it is better to crush the pits in order to obtain the oil that is therein found. Reference to the tables will show the futility of so doing with any such object in view. The actual amount of oil contained in the pit is so very small, and it is so disseminated through the hard material composing the pit, that its extraction by other than purely chemical means is not possible. Hence there is nothing to be gained in this respect by crushing the pits, and great injury is done the quality of the oil. Unfortunately the machines thus far constructed for the crushing of the olives without breaking the pits are imperfect, and not as practical as could be desired.

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Though many inventions exist having this object in view, they are so imperfect that we know of none that it would be safe to recommend at this moment. The nearest approach to good practical results, when working on a large scale, ever seen by the writer, was an adaptation of the old "arrastra" principle. Instead of one large mill-stone revolving in a large circle, two mill-stones revolving on a very short path are used. Instead of hitching a mule to the outer end of the beam, the crushers are made to revolve rapidly by machinery. Care must be taken not to crush too rapidly, for over a certain velocity so much heat is generated by friction that the oil is "burned"—*i. e.*, heated till it acquires a bad taste. Instead of allowing the heavy mill-stones to rest their full weight on the bottom of the crushing-trough they are made to revolve an inch or so above it. Then, by putting a sufficient quantity of olives in at a time, the flesh is well broken and lacerated by friction, one olive against the other. The height can be regulated by means of screws so that the same machine can be used for the grinding of the residues for inferior oil. The machines that accomplish this tearing of the flesh without breaking the pulp are very diverse in principle, but none have been found thus far to be equal, on a large scale, to the mill-stones revolving in the air.

Whatever be the machine used to crush the olive, it should never be made of iron. The juice of the olive is rich in vegetable acids, most important of which is tannic acid. The action of these acids on the iron is most rapid and marked. That of tannic acid on iron results in the formation of *ink*, which imparts a characteristic taste to the oil, as well as a black color, almost ruining it for consumption. These evil effects are avoided by the use of GRANITE, both for the crushing-weight and for the bottom of the crushing-trough. In case it is not possible to obtain granite in time, very little evil will result if well-tinned iron is used. As a rule, however, it is cheaper and easier to use granite, which has the advantage of being much cleanlier than tinned or untinned iron. The market is well supplied now with either granite or tinned iron oil-mill machinery.

OIL PRESSES.

Once the olives have been reduced to a mass of well-ground pulp (the pits being broken or not as the case may be), it is necessary to put this under a powerful press and separate the liquid part, composed of juice, oil, etc., from the pulp, pits, etc.

In Europe the pulp is transferred at once into large, strong, circular, grass mats holding about twenty-five pounds. These are piled one upon the other under the press, and the pressure applied slowly till the oil and watery juice cease to exude. The great advantage of the mats is that they enable the pulp to be quickly handled, and maintain the column of broken olives in the most convenient position possible, without the aid of perforated metal cylindrical sleeves, etc. The oil from this first operation is called the "first pressing." When once the mass seems to be thoroughly dry, the press is "unkeyed" and the mats emptied of their contents, which are again crushed under the mill-stones. Before refilling the mats the comparatively dry mass is moistened with water at normal temperature and made into a stiff paste for convenience in handling; the mats are then refilled and the whole is again pressed, the resulting oil being the "second pressing." In case it is so desired

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this operation is repeated once or twice again for the "third" and "fourth" "pressings." The oil from these successive pressings is inferior to the one preceding. As a rule hot water is applied to the paste to extract the "third pressing," the quality of the oil being so inferior to the two preceding pressings that it cannot be mixed with them.

While the finest oil comes from the first pressing, it is in some places the custom to mix the first and second pressings together, there being little difference in quality, *if no hot water is used*, that for ordinary use no great harm results. When oil of the highest grade is made, the pressings are kept separate. In California it is rare to find more than two pressings made, and then hot water is not used. In some cases a third pressing with hot water is made for inferior grades of oil. It is not at present considered economical in this State to make a fourth pressing.

Whatever be the grade of oil made, grass mats or strong cloth must be used to hold the pulp together while under the press. The grass mats of Europe are for the most part too expensive for general use in this State, so cloth has been substituted for them. Mats cost now from $1 to $2 each in this State, while cloth costs from 35 cents to 60 cents in sizes large enough to accomplish the same result. Several kinds of cloth have been tried in this State with varying success. Mr. Ellwood Cooper and others use "Russian crash." At the University Experiment Station several kinds of cloth were tried during the season of 1893–94. No Russian crash could be obtained in time for experiment, so linen "huck," various grades of "duck," and sail cloth were tried. The linen huck proved a failure; the "duck" was better, but not an entire success; while the sail cloth proved quite satisfactory. It is hoped that in a very short time arrangements will be completed for the manufacture in California of mats similar to those used in Europe.

Whatever be the material used to hold the pulp during the pressing, certain kinds of presses are more convenient than others. On the market to-day there are many presses that are adapted only for the use of mats, and others equally well adapted for the use of cloth or mats. The press in use at the University of California is adapted to both. We give below a cut of this press. Examination of this figure will show that the "follower" on the end of the press screw is round and unattached to the columns that support the screw. Also that this "follower" fits into a hard metallic "sleeve." This is a great convenience, in that it enables the workman to put twenty-five pounds of pulp on a piece of cloth, fold over the ends, and place the whole in the sleeve with great rapidity; at the same time there is no trouble about maintaining the column in a vertical position while enormous force is brought to bear on the whole. It should be noted, also, that the point of application of the force is fixed, which many consider a great convenience. Whatever be the kind of press used, it should be either of well-tinned steel, or should have a loose tin covering put on the bottom so as to avoid as much as possible direct contact of the olive juice with the rough iron for reasons already given. At the University Experiment Station it was found necessary to use the tin bottom-cover on this account, the press being of untinned iron. As a rule it is found that hydraulic pressure is not necessary for the first and second pressings, the force of two men on the lever being ample. It should be noted that nothing is gained by rapid pressure; on the contrary, it seems that less oil is obtained in

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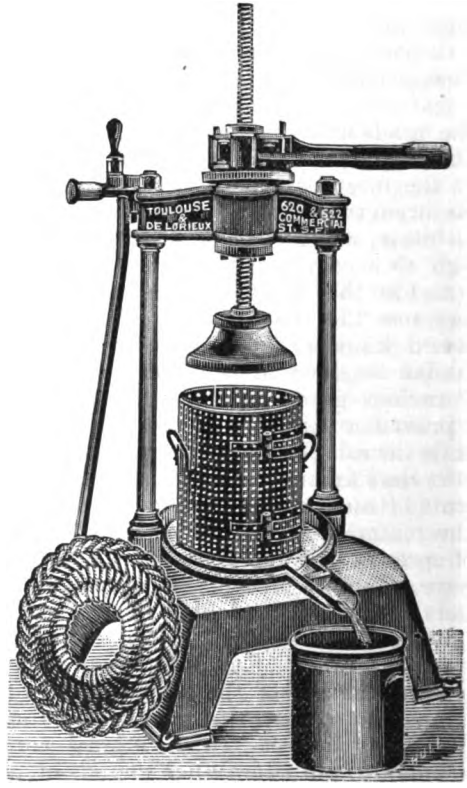
this way than if the same power be applied very slowly. It is customary to press gradually for a moment until the juice seems to run freely, then wait fully a minute till the flow of juice has almost ceased before again keying up the press. There will be far less juice coming from the press if the olives have been evaporated—but this is a mere matter of detail in separating the oil from the juice. The quality and quantity of oil are not affected. Though it is easier to express a small quantity it is harder to separate the oil afterwards, unless water be added to dilute the juice.



OIL PRESS used in the oil-room of the Central Station, showing European grass mats, perforated "sleeve," etc.

The press-room should be separate from that in which the olives are crushed, but on the same level; and if possible a floor above that in which the "separator" is kept. It is most economical to have the olives stored on the floor above the crushing-room. In this way there is a great saving of time in the handling, besides greater cleanliness.

THE "SEPARATOR."

One of the most troublesome processes in the making of olive oil is the separation of the oil from the watery juice and pulp after it comes from the oil press. The universal custom thus far has been to collect this mixture of water, oil, and pulp as it drips from the press and leave it

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several hours; then skim off the oil from the surface as fast as it rises. The makers of the highest-priced European oil are very careful not to allow their highest grades to remain in contact with the juice for more than four hours. The makers of cheap *peasant oil*, on the other hand, are very careless about this, and have, in consequence, a product that sells for very little on the market. It makes no difference whether the olives have been evaporated or not. It is distinctively a bad practice to leave the oil any length of time on its own juice or dregs. The sooner the oil is separated from the fermentable juice the less danger there is of putting an oil on the market with a rank taste, which forms the beginning of rancidity.

There seems to be an impression on the minds of many oil-makers of this State that the mixing of oil and water is bad for the oil. While it is certainly true that it is bad to mix oil and *dirty* water, it is equally true that pure clean water in no way affects the oil. The mixture is purely *mechanical*, and, unless the water be so very alkaline as to render it unfit for drinking purposes, no possible harm results. The value of water at normal temperatures for diluting the olive juice cannot be overestimated. I have seen oil-makers in this State who were still skimming the oil off the drip from the press six months after the olives had been pressed. The fruit had been evaporated, and the juice was so concentrated that it was impossible to separate the oil any sooner without the use of water at a normal temperature, to so dilute the juice as to allow the oil free room to rise to the top by reason of its natural lightness. Had this concentrated juice been mixed at once with a quantity of fresh, pure spring water the oil could have been separated within a few hours by skimming. Even after the hot weather had begun the oil would have not been hurt in any way by immediate separation by mixing with water. But the contact of oil and a mass of fermentable matter as the juice at comparatively high temperature of summer was simply inviting ruin, for both moulds and ferments are favored in their development by heat.

The evils of long contact have been realized for a long time by all rational European oil-makers, and various devices have been imagined to do away with it. For hand-skimming, besides being bad for the oil, is very expensive, requiring much labor and expensive rooms and vessels. The principle of water-separation had been tried for years in Europe, but the most practical contrivance was seen in the oil-room of the Royal School of Agriculture at Portici, near Naples, Italy. It is due to the kindness of Prof. E. Mingioli, of that institution, that the writer was enabled to see the apparatus at work.

The apparatus, as shown in the plate, consists essentially of a tin tank, about four feet high by two in diameter. This tank is kept constantly full of fresh water, by means of a pipe connected with some adequate supply, the level being regulated by means of stop-cock outlets.

The juices from the pressing, charged with oil in a finely emulsified state, are made to flow into the tank near the bottom, through a small "drum," perforated laterally. Immediately below this oil-escape is a large flat "drum," perforated on the top, from which a stream of fresh water escapes in vertical jets. These two currents of oil and fresh water at once mix, and the oil passes upward, by reason of its lightness. Being in very small drops, it is washed of its heavier impurities (tissue, coloring matter, etc.), and reaches the top of the column of water in an almost perfectly clean state, having left all grosser impurities to be

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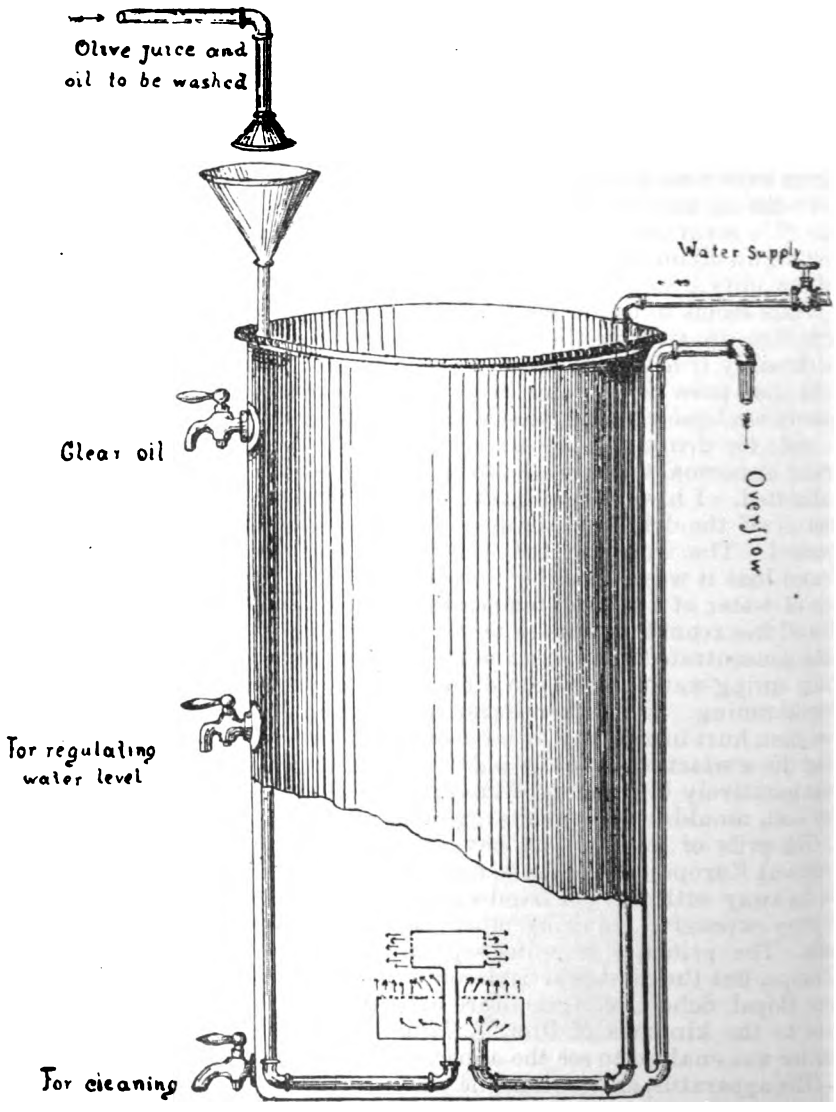

THE OIL SEPARATOR.

carried off through an escape pipe at the bottom. When sufficient oil has been collected at the top, a stop-cock is opened and the oil runs off ready to be clarified. The level once established, the apparatus will work uninterruptedly for a long time without being cleaned out. Though the small quantities of olives at the disposal of the Station did not permit of any long-continued test of the process, yet it was found that

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the larger the quantities used, the better the separator worked. No doubt it is susceptible of many small improvements, such as automatic regulators, etc.; still, on the whole, it was found to work very well indeed, and to be a vast improvement on the method of hand-skimming.

A model of this "separator," together with oil made at the Station, and olives, olive pits, etc., can now be seen in the Agricultural Building at the State University, Berkeley.

CLARIFICATION.

The oil that comes from the separator, or from the hand-skimmer, is not yet ready for use. Besides having some very fine particles of pulp suspended in it, there is a prickly taste to it as it is swallowed. These must be gotten rid of before the oil is marketable. The minute particles of vegetable tissue will soon fall to the bottom of the oil tank if the temperature of the room in which the oil is kept remains at the normal cool summer temperature. If it falls to 45° F., almost all precipitation is stopped. In Europe, where oil is not filtered "to death," as in this country, after standing a week or so it is racked off its dregs and passed through about three inches of cotton-batting, and is then ready for use as "new oil"; that is to say, oil with a slight prickly taste.

This prickly sensation in the throat is due to a minute quantity of acrid substances in the juice that remains in suspension on account of their finely divided state. Each variety of olive has a different quantity of these in its fruits, so this prickly taste will vary greatly according to locality, state of maturity, variety, etc. Time only is required to get rid of this sharp taste. It is a mistake to suppose that heat or the action of the air is necessary in this process, beyond the action of a gentle normal heat in maintaining the oil sufficiently liquid to enable the acrid substances to precipitate. It has not yet been demonstrated that there is any chemical change that takes place in the oil thus charged. In case there be chemical reactions taking place in the new oil, they must be mere oxidations, and the quantity of free oxygen in the oil is ample to bring about the destruction of these substances, if it is granted that this be true. The weight of evidence, however, seems to be that no chemical reaction takes place in the process of getting rid of this taste, but that it is purely a mechanical one.

Hence, the practice of the so-called "maturing" of olive oil by exposure to heat and air is bad. For while there is no necessity of either heat or air in getting rid of the prickly taste, if the oil be thus exposed for any length of time, the oil itself will oxidize; that is, it will become rancid. Thus, we see that we have everything to lose and absolutely nothing to gain by the exposure of oil to air and heat while undergoing this supposed process of "maturing." Those who practice this got their ideas of it from the peasants of Europe, who certainly do practice this pernicious custom. But, to quote the words of Napoleone Passerini, of Florence, Italy, "The peasants prefer an oil with a rancid taste to one without it." The presence of a large number of this class in California accounts for the spreading of these ideas among those who do not know peasant traits. It is certainly true that oil thus "matured" brings a far lower price on the market than oils not so treated. It is the practice of those who get the highest prices for their oils to keep them, as much as possible, from the air and heat; also, to filter them as little as they can.

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Never is a very high-priced oil filtered, least of all with charcoal. The use of charcoal is necessitated by the presence of some specially rank taste that must be gotten rid of. Too much attention should not be paid to the opinions of ignorant peasants, who are accustomed to making and tasting only the most inferior oils (and wines) of the countries from which they come.

The American market requires that olive oil should be put in glass, and be perfectly clear and brilliant. This necessitates careful filtration. Strictly speaking, olive oil should not be filtered at all, for by the process of filtration it loses a great deal of its characteristic taste and odor. Highly clarified oil is prettier to look at, but is not as agreeable to the taste as that which has been allowed to deposit naturally its solid matter. The oftener an oil is filtered, the more neutral in taste it becomes. In Europe, oil is seldom clarified so highly as in America. There, simple cotton-batting is used for oil intended for domestic purposes, but in California, where only the most brilliant oil is in demand, something less porous than cotton-batting is required.

In the oil-room of the Station, experiments were made with cotton-batting, "glass wool," asbestos, and filter-paper. All but good filter-paper, such as is used in chemical laboratories, was found to be unfit for purposes of clarification. Even with good filter-paper, some varieties of oil were found to require two filtrations before becoming perfectly clear and brilliant. It was also noted that where oil was at once filtered after separation, there was a tendency to become cloudy after a month or so in the bottle. Hence, in the clarification of oil, care should be taken to use only paper of such good quality as will necessitate but one filtration.

It was found that it was impossible to filter olive oil in a room where the temperature was below 45°. Of course no heat should be used, but the temperature should be at least 50° F.

It is to be hoped that those who are fond of the true olive flavor and aroma in pure olive oil will encourage the mill-owners in this State to treat their oil as a good wine merchant treats his best wine; that is, to maintain it at an even normal temperature and rack off its dregs as long as there are dregs deposited. Treated in this way, oil will become almost as clear and brilliant as filtered oil, and will not be a neutral-tasting, greasy liquid, differing little from cotton-seed or any other oil now so extensively used to adulterate olive oil. It is far easier to adulterate a perfectly neutral oil than one with a characteristic taste. Many oil-makers assure me that they will be only too glad to put on the market unfiltered oil, provided there is a demand for it. Once the taste for unfiltered oil has been acquired, no neutral-tasting, "greasy" oil can be tolerated.

ANALYSES OF OLIVES AND OLIVE OIL.

The twenty-four analyses made in the laboratory of the Central Station during the two previous seasons have been placed in the table below with those of the season of 1893–4, thus giving more extended data for comparison of the value of varieties, and their relative adaptation in the various parts of the State.

It will be noted that the tables do not contain the iodine absorptions as in previous years; also, that a column showing the number of olives necessary to make 100 grams has been added. The reason for this

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insertion is that the reader may be enabled to form a pretty accurate idea of the relative size of the fruit without troublesome cross references. This tabulation, taken with Column 1, which shows the proportion of pits and flesh found in the fresh fruit, enables the reader to determine at a glance the value of any variety for pickling. Take, for example, Polymorpha and Redding Picholine; in one case it takes 13 olives to make 100 grams, in the other it takes an average of 79 olives. Moreover, in the 13 Polymorphas there is 17 per cent of pit and 83 of flesh, while in the 79 Redding Picholines there is an average of 24.41 per cent of pit and 75.58 of flesh. Keeping in mind that for pickles the object is to have an olive that, while being as large as possible, has the smallest possible pit, one has little trouble in judging of the relative merit of whatever varieties he may have in mind.

Column 2 shows the percentage of oil it is possible to extract from the whole fruit by the most careful chemical processes. It shows also the uselessness of taking into consideration the oil contained in the pits. Even were this pit-oil available and unobjectionable, the actual quantity would not pay for the trouble of extraction; but such very small quantities disseminated throughout a mass of hard material, renders their expression by mechanical means a problem of no practical interest.

But aside from the uselessness of attempting to extract the pit-oil, the kernel imparts a disagreeable taste to the oil of the flesh with which it comes in contact, and impairs its keeping qualities.

It is Column 3 that serves chiefly for the study of the values of olive varieties. In the second row of Column 1 we find the percentage of flesh in the whole fruit; in the second half of Column 3 we find what part of this flesh is oil, and what part refuse matter.

Table II is a comparative table of averages of those varieties of which two or more samples were received at the Station. It is to be regretted that the tables are so incomplete; but it was too late in the season to make proper arrangements to obtain more samples when the work was assigned to the new assistant.

It is hoped that next year olive-growers from all parts of the State will send samples of the varieties they may have to the Agricultural Experiment Station in Berkeley, in order that this study may be made as complete as possible. It is only with the coöperation of the olive-growers that the problem of adaptation of varieties to soil and climate can be solved.

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TABLE I. PARTIAL ANALYSES OF SOME SAMPLES OF CALIFORNIA OLIVES AND OILS. (CROPS OF 1890-94.)

Number	Variety.	Locality.	Date of Picking.	No. of Olives in 100 Grams	1 Proportion of Pits and Flesh in Fruits.		2 Percentage of Oil in Whole Fruit Possibly Yielded by		3 Percentage of Oil Contained in Fresh	
					Pits.	Flesh.	Pits.	Flesh.	Pits.	Flesh.
1	Manzanillo	Fresno	Nov. 4, 1890		13.00	87.00	.53	19.23	4.10	22.01
2	Manzanillo	Berkeley	Jan. 20, 1891		16.00	84.00	.51	21.38	3.20	25.45
27	Manzanillo	Pomona	Nov. 13, 1890	16	22.50	77.50	.66	15.10	3.00	20.00
40	Manzanillo	Mission San José	Dec. 5, 1893	32	17.00	83.00		20.84		25.10
86	Manzanillo	Pomona	Dec. 26, 1893	15	12.00	88.00	.50	19.60	4.23	22.30
	Average			21	16.10	83.90	.55	19.23	3.84	22.57
6	Nevadillo Blanco	Fresno	Nov. 4, 1890		17.50	82.50	1.60	18.02	6.60	22.00
7	Nevadillo Blanco	Mission San José	Jan. 7, 1891		24.00	76.00	1.06	23.94	4.40	31.50
8	Nevadillo Blanco	Berkeley	Jan. 7, 1891		25.00	75.00	1.05	22.72	4.20	30.30
17	Nevadillo Blanco	Mission San José	Dec. 16, 1891		20.50	79.50	.94	25.65	4.70	32.06
33	Nevadillo Blanco	Pomona	Nov. 22, 1893	28	15.00	85.00		19.30		22.72
39	Nevadillo Blanco	Mission San José	Dec. 5, 1893	70	25.00	75.00		15.35		20.50
58	Nevadillo Blanco	Biggs	Dec. 11, 1893	30	18.00	82.00		16.22		19.00
64	Nevadillo Blanco	Chico	Dec. 21, 1893	19	18.00	82.00		18.98		23.15
82	Nevadillo Blanco	Pomona	Dec. 26, 1893	29	17.00	83.00	.75	18.50	4.44	22.30
	Average			35	20.55	80.00	1.08	19.85	4.86	24.83
12	Mission	Mission San José	Jan. 8, 1891		23.50	76.50	.94	19.07	4.00	24.90
23	Mission	Newcastle	Mar. 9, 1891		20.00	80.00	.61	16.55	3.07	20.68
24	Mission	Mission San José	Dec. 16, 1891		16.50	83.50	.40	18.72	2.40	21.40
25	Mission	Fresno	Jan. 12, 1892		18.00	82.00	.70	23.08	3.70	28.15
26	Mission	Newcastle	Jan. 14, 1892		17.50	82.50	.50	17.50	3.20	21.31
42	Mission	Mission San José	Dec. 5, 1893	47	25.00	75.00		16.45		21.90
43	Mission	Mission San José	Dec. 5, 1893	42	26.00	74.00		15.31		20.00
53	Mission	Biggs	Dec. 11, 1893	26	17.00	83.00		17.78		21.40
62	Mission	Livermore	Dec. 15, 1893	34	25.00	75.00		22.73		30.29
63	Mission	Chico	Dec. 21, 1893	17	15.00	85.00		20.75		24.40
71	Mission	El Quito	Dec. 22, 1893	34	22.00	78.00		15.01		19.20
79	Mission	Pomona	Dec. 26, 1893	20	15.00	85.00	.52	19.46	3.50	22.90
87	Mission	St. Helena	Dec. 28, 1893	22	15.00	85.00		18.70		22.00
	Average			30.25	19.60	80.00	.61	18.77	3.44	22.94

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13	Rubra	Fresno	Feb. 5, 1891		19.50	80.50	.80	17.69	4.10	21.97
14	Rubra	Fresno	Jan. 12, 1892		15.00	85.00	.80	20.00	5.20	23.53
15	Rubra	Newcastle	Jan. 14, 1892		21.00	79.00	.80	27.57	4.00	34.90
32	Rubra	Pomona	Nov. 19, 1893	35	18.00	82.00		17.88		21.57
35	Rubra	Niles	Dec. 7, 1893	38	20.00	80.00		11.88		14.85
46	Rubra	Biggs	Dec. 11, 1893	42	17.00	83.00		15.24		18.40
72	Rubra (?)	Biggs	Dec. 23, 1893	42	18.00	82.00		18.40		22.40
73	Rubra	Biggs	Dec. 23, 1893	47	16.00	84.00		14.85		17.70
83	Rubra	Pomona	Dec. 26, 1893	41	16.00	84.00	.91	21.44	5.70	25.53
	Average			40.83	17.80	79.94	.82	18.33	4.75	22.28
5	Atroviolacea	Fresno	Nov. 4, 1890		23.70	76.30	1.19	13.78	5.00	18.10
16	Atroviolacea	Newcastle	Jan. 14, 1892		16.00	84.00	.73	21.90	4.40	26.70
37	Atroviolacea	Mission San José	Dec. 5, 1893	48	25.00	75.00		20.83		27.80
55	Atroviolacea	Biggs	Dec. 11, 1893	41	20.00	80.00		13.74		17.17
75	Atroviolacea	Biggs	Dec. 23, 1893	48	25.00	75.00		14.69		19.58
	Average			45	21.94	78.00	.96	16.98	4.70	21.87
11	Redding Picholine	Mission San José	Jan. 8, 1891		29.00	71.00	1.88	21.87	6.50	30.80
18	Redding Picholine	Mission San José	Dec. 16, 1891		24.50	75.50	1.17	22.99	4.70	30.70
34	Redding Picholine	Auburn	Nov. 27, 1893	78	21.00	79.00		17.08		21.60
52	Redding Picholine	Biggs	Dec. 11, 1893	91	25.00	75.00		13.27		17.70
60	Redding Picholine	Livermore	Dec. 15, 1893	67	23.00	77.00		20.80		27.00
65	Redding Picholine	Chico	Dec. 21, 1893	80	24.00	76.00		15.25		20.10
	Average			79	24.41	75.58	1.52	18.64	5.60	24.65
20	Oblonga	Fresno	Jan. 12, 1892		18.00	82.00	.90	14.95	4.60	18.23
41	Oblonga	Mission San José	Dec. 5, 1893	40	25.00	75.00		15.10		20.10
47	Oblonga	Biggs	Dec. 11, 1893	25	15.00	85.00		10.85		12.80
61	Oblonga	Livermore	Dec. 15, 1893	37	21.00	79.00		20.50		26.00
92	Oblonga	Berkeley	Jan. 4, 1894	67	20.00	80.00		9.29		11.61
76	Oblonga	Biggs	Dec. 23, 1893	34	17.00	83.00		11.10		13.40
	Average			40.60	19.00	80.66	.90	13.63	4.60	17.02
22	Columbella	Fresno	Jan. 12, 1892		17.00	83.00	.50	15.20	3.10	18.35
45	Columbella	Mission San José	Dec. 15, 1893	49	25.00	75.00		16.32		21.80
56	Columbella	Biggs	Dec. 11, 1893	28	15.00	85.00	.63	13.53	4.20	16.00
80	Columbella	Pomona	Dec. 26, 1893	19	15.00	85.00	.68	17.39	4.62	20.05
91	Columbella	Berkeley	Jan. 4, 1894	70	20.00	80.00		14.13		17.65
	Average			41.50	18.40	81.60	.60	15.31	3.93	18.77
3	Pendulina	Fresno	Nov. 4, 1890		14.80	85.20	1.04	17.40	7.00	20.50
84	Pendulina	Pomona	Dec. 26, 1893	29	13.00	87.00	.92	18.81	7.10	21.70
77	Pendulina (?)	Biggs	Dec. 23, 1893	13	15.00	85.00		10.00		11.70
	Average			21	14.26	85.66	.98	15.40	7.05	21.30

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PARTIAL ANALYSES OF SOME SAMPLES OF CALIFORNIA OLIVES AND OILS. (CROPS OF 1890-94.)—Continued.

Number.	Variety.	Locality.	Date of Picking.	No. of Olives in 100 grams.	1 Proportion of Pits and Flesh in Fruits.		2 Percentage of Oil in Whole Fruit possibly yielded by		3 Percentage of Oil contained in Fresh	
					Pits.	Flesh.	Pits.	Flesh.	Pits.	Flesh.
21	Præcox	Fresno	Jan. 12, 1892		17.00	83.00	.60	12.87	3.09	15.40
54	Præcox	Biggs	Dec. 11, 1893	48	19.00	81.00	1.10	16.86	6.06	20.00
93	Præcox	Berkeley	Jan. 4, 1894	71	20.00	80.00	.72	10.67	3.60	13.35
	Average			59.50	18.00	81.00	.80	13.48	4.50	16.51
57	Uvaria	Biggs	Dec. 11, 1893	39	25.00	75.00		11.00		14.66
74	Uvaria	Biggs	Dec. 23, 1893	44	27.00	73.00		9.64		13.20
81	Uvaria	Pomona	Dec. 26, 1893	33	22.00	78.00	1.05	11.38	4.76	17.40
	Average			38.30	24.66	75.36		11.38		15.08
19	Atrorubens	Fresno	Jan. 12, 1892		18.50	81.50	.80	21.26	4.20	26.10
49	Atrorubens	Biggs	Dec. 11, 1893	28	15.00	85.00	.71	16.68	4.11	19.60
	Average				16.75	83.25	.75	18.97	4.15	22.85
50	Nigerina	Biggs	Dec. 11, 1893	36	15.00	85.00	.94	18.16	6.24	21.31
85	Nigerina	Pomona	Dec. 26, 1893	23	15.00	85.00	.53	22.35	3.46	26.30
	Average			29	15.00	85.00	.73	20.25	4.85	23.85
59	Columbaro	Biggs	Dec. 14, 1893	23	15.00	85.00	.50	17.73	3.38	20.85
78	Polymorpha	Biggs	Dec. 23, 1893	13	17.00	83.00	.66	13.65	3.90	16.40
88	Lucques	Livermore	Dec. 28, 1893	67	30.00	70.00	1.00	13.06	3.32	18.70
89	Piangente	Berkeley	Jan. 4, 1894	76	22.00	78.00	.86	13.48	3.92	17.30
90	Hervaza	Berkeley	Jan. 4, 1894	21	17.00	83.00	.37	12.98	2.20	15.60
36	Rock's No. 57	Niles	Dec. 7, 1893	65	21.00	79.00		7.12		9.30
9	Seedling, No. 10	Berkeley	Jan. 4, 1894	77	25.00	75.00		13.90		18.53
48	Amellau	Biggs	Dec. 11, 1893	19	16.00	84.00	48	14.00	3.02	17.50

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38	No. 16, Row E	Mission San José	Dec. 8, 1893	79	32.00	68.00		19.00		28.00
67	Razzo	El Quito	Dec. 22, 1893	52	20.00	70.00	1.08	23.59	3.65	33.70
70	Grossajo	El Quito	Dec. 22, 1893	53	28.00	72.00	1.03	25.03	3.72	34.76
68	Correggiolo	El Quito	Dec. 22, 1893	53	33.00	70.00	1.20	20.29	4.07	28.98
66	Frantojo	El Quito	Dec. 22, 1893	74	30.00	70.00	1.00	18.69	3.36	26.70
69	Morajolo	El Quito	Dec. 22, 1893	55	33.00	67.00	1.45	21.93	4.43	32.72
44	Regalis	Mission San José	Dec. 5, 1893	34	22.00	78.00	1.19	16.85	5.47	21.60
51	Becca Rufa	Biggs	Dec. 11, 1893	58	19.00	81.00	1.10	21.05	6.00	25.29

TABLE II. AVERAGES BY OLIVE VARIETIES, WITH MAXIMUM AND MINIMUM.

Variety.	Number of Samples Examined	Percentage of Oil in Fresh Fruit.				Number of Olives in 100 grams.			Percentage of Flesh in Whole Fruit.			Percentage of Pit in Whole Fruit.		
		Maximum	Minimum	Average	Variation	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Rubra	9	34.70	14.85	22.28	20.05	47	35	40	85	79	79	21	15	19.60
Nevadillo Blanco	9	32.06	19.00	24.83	13.06	70	19	35	85	75	80	25	15	20.00
Mission	13	30.29	19.20	22.94	11.09	47	17	30	85	74	80	26	15	19.00
Redding Picholine	6	30.80	17.70	24.00	13.10	91	67	79	79	71	75	29	21	24.00
Atrorubens	2	26.10	19.60	22.85	6.50	28	28	28	85	81	83	18	15	16.00
Oblonga	5	26.00	11.61	17.02	14.21	67	25	40	85	75	80	25	15	19.00
Nigerina	2	26.30	21.31	23.85	5.00	36	23	29	85	85	85	15	15	15.00
Manzanillo	5	25.45	20.00	22.30	5.10	32	15	21	88	77	83	22	12	16.00
Pendulina	3	21.50	11.70	21.30	10.00	29	13	21	87	85	85	15	13	14.00
Præcox	3	20.80	13.35	16.51	7.45	71	48	59	83	80	81	20	17	18.00
Uvaria	3	17.40	13.20	15.08	4.20	44	33	38	78	73	75	27	22	24.00

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Examination of Table I brings out the importance of a close study of soil, climate, and varieties before undertaking to plant an olive orchard. It will be seen that there are varieties that yield a very high percentage of oil, and others that do not. Further, it appears that the same variety, on different soils, etc., may vary as much as 20 per cent in the amount of oil yielded, while the crop on each may, to all appearances, be equally heavy. Thus the Rubra, in one place, contains as much as 34.90 per cent of oil, and in another locality has but 14.85 per cent—a difference sufficient to ruin an olive-grower in a few years. This variation in oil yield is most easily studied in Table II, in which the maximum, minimum, and averages have been conveniently arranged.

It will be noticed (Table II) that in the eleven varieties of which more than two samples were received, the difference between the maximum and minimum of oil in fresh fruit varies very greatly: thus, while in the Rubra the difference is 20.05, in the Uvaria it is only 4.20—thus showing for the latter a greater uniformity in oil percentages for the State at large. The following list comprises the commonest varieties now growing in California, and the table is arranged in the order of highest to lowest variations between maximum and minimum oil percentage:

Variety.	Variation in Oil.
Rubra	20.05
Oblonga	14.21
Redding Picholine	13.10
Nevadillo Blanco	13.06
Mission	11.09
Pendulina	10.00
Præcox	7.45
Atrorubens	6.50
Manzanillo	5.10
Nigerina	5.09
Uvaria	4.20

The table shows what a matter of "guess work" the selection of varieties for orchards in the State has been thus far, and emphasizes the importance of the work undertaken by the Agricultural Experiment Station in bringing out all of these various characteristics.

It would not be safe to pass judgment too hastily, taking into consideration the relatively small number of analyses at our command, yet it will at once be seen that there are varieties that seem to be better adapted for general planting than others. Take, for example, the Mission. This is the oldest variety cultivated in California, and we have examined thirteen samples; yet it stands as a very good oil variety, never falling below 19.20 per cent of oil, and an average of 30 olives in 100 grams (144 in one pound). This fact, taken with the experiments in the oil-room, show it to be one of the preëminently safe varieties to plant. It gives an oil of very good quality, and one that keeps its marketable qualities in an exceptionally good manner.

What is said of the Mission can be said of the Manzanillo, which, while being a trifle larger than the Mission, is a more regular bearer, and fully as hardy.

The Nevadillo Blanco, while a smaller olive than either of the other two, is, by reason of its high average in oil, and its regularity as a bearer, one of the olives of the future.

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The Redding Picholine shows itself unworthy of the place it has in the olive plantations of the State. Though it is a good bearer and a vigorous grower, it is the smallest olive of any of the varieties thus far found in California. It has more pit and less flesh than any other variety. Next to the Rubra it varies more than any other in the above table, and the oil-room experiments show it to give an inferior product. Of all the oils made this year in the Station oil-room, that of the Redding Picholine was the "greasiest" and the first to solidify, assuming the appearance of partly melted, yellowish lard.

The Uvaria was a disappointment, the general impression being that it was a very good oil variety, so far as regards quantity.

The Rubra, in spite of its uncertainty as to richness in oil, is a good variety when well adapted to its surroundings. The Rubra oil made at the Station was of a very high degree of excellence, and stood cold weather very well.

For the first time we have analyses of the leading Italian varieties, *i. e.*, Grossajo, Razzo, Frantojo, Correggiolo, and Morajolo. From the very high yield of oil, when we take into account that the Mission on the same soil gives but 19.20 per cent of oil, we are led to conclude that these new varieties will be of great importance in the future.

Further comment is not deemed wise at this time, owing to the fact that there are too few varieties of which samples were received from more than one locality. In another year, with the coöperation of the olive-growers of the State, it will be possible to discuss more fully the results. They are given to the public as they stand, as the only data existing at this moment.

The thanks of the Department are extended to Messrs. Alfred Wright and J. S. Calkins of Pomona, J. Rock of Niles, Hatch & Rock of Biggs, and Louis Mel of Livermore, for their generous donations of samples of olives in lots large enough to be made up into oil.

DRIED OLIVES.

While pickling the olive is by far the most common of all methods of its preparation, we frequently find dried olives used on the tables of those who duly appreciate the healthful and nourishing qualities of this fruit. Quite recently in California, this method of preparation has suggested itself to many who did not care for olives prepared in the commoner ways. Perhaps one reason that the majority of consumers did not appreciate the dried as much as they did the pickled olive, is because an unfortunate selection of varieties was made for drying. In Europe, where the use of dried olives is quite common, it has been found that but few of the many cultivated varieties lend themselves to this method of preparation, because of the natural and excessive bitterness of the majority of the varieties. Even in Europe, olives thus prepared are seldom used as an article of food, as is the case with the pickled fruit Dried olives are there, as a rule, used as a relish, very much as the large green pickled olive is with us. The Europeans generally eat dried olives with salt; but even then, they use them as a relish and not as an article of food.

The preparation of olives in this way is very simple indeed. The berry is allowed to hang on the tree till it is jet-black, and if there is no danger of losing the crop from winds, birds, and frost, they are

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allowed to become somewhat shriveled before gathering. They are then sun-dried and stored in a dry place. Artificial heat is never used, though there can be no objection to it, if used in moderation.

It is hoped that during the coming season sufficient quantities of all the varieties grown in California will be donated to the University in order to enable the Experiment Station to make thorough tests as to those varieties best adapted for this purpose.

Thus far the variety that seems to be best adapted for drying is the Atroviolacea.

THE ASH OF GRAPES.

By F. T. Bioletti.

The subject of the ash analysis of various California fruits, and its relation to soil exhaustion and fertilization, has been treated of in former bulletins of this Station. The composition of the ash of California grapes and the drain of the grape crop upon the soil, however, has not been investigated. The analyses of which the results are detailed in this paper are an attempt to throw some light upon this matter, and by means of comparison with European analyses and the analyses of other fruits, to gain some knowledge as to the amount of soil ingredients taken from the soil by a crop of grapes or wine, and the liability to the need of fertilizers, either now or in the future.

The ashes of five samples of grapes and one of wine were analyzed, with the results which are tabulated below. The samples investigated were the following:

No. 1. *Thompson's Seedless*, grown at the Agricultural Experiment Station near Tulare; a good mature sample of the variety; received at Berkeley on September 25, 1893.

No. 2. *Gros Colman*, grown at the Agricultural Experiment Station near Paso Robles; grapes very varied in size and hardly mature; received October 13, 1893.

No. 3. *Muscat of Alexandria*, grown at the Tulare Agricultural Experiment Station near Tulare; a fair, average sample; received October 16, 1893.

No. 4. *Muscat raisins*, grown by J. T. Alpeter, on the vineyard of R. H. Loughridge, at Woodland, Yolo County; sample of medium-sized, well-cured fruit.

No. 5. *Seedless Sultana raisins*, received from the same place; small, but well cured.

No. 6. *Mataro* (*wine*), made at the Agricultural Experiment Station Cellar, Berkeley, from grapes received from San José, Santa Clara County; a fair average sample of dry, red wine; analyzed when two years old.

The following table is compiled from data kindly furnished by Mr. G. E. Colby, by whom the determinations were made:

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Composition of the Grapes.

Sample.	Whole Grape.		Must.		
	Water—Per cent.	Organic Matter and Ash—Per cent.	Solid Contents by Spindle—Per cent.	Sugar by Copper Test—Per cent.	Acid as Tartaric—Per cent.
1. Thompson's Seedless	81.71	18.29	25.05	24.12	0.31
2. Gros Colman	80.77	19.33	15.20	15.11	0.33
3. Muscat of Alexandria	77.88	22.12	24.80	24.43	0.48

The first two columns are the result of weighing a known quantity of fresh grapes after they had been subjected to a temperature of 100° C. for two weeks in a drying oven.

The results of my investigation of the samples described above are given in the following tables. The ashes were obtained by the method of successive leachings, and analyzed according to the ordinary method of ash-analysis:

Ash and Nitrogen Contents.

Sample.	Locality.	Fresh Fruit.		Dried for two weeks.	
		Pure Ash—Per cent.	Nitrogen—Per cent.	Pure Ash—Per cent.	Nitrogen—Per cent.
1. Thompson's Seedless	Tulare	.513	.174	3.027	.95
2. Gros Colman	Paso Robles	.452	.231	2.349	1.20
3. Muscat of Alexandria	Tulare	.658	.199	2.968	.90
4. Muscat Raisins	Woodland	.402	----------	1.451	----------
5. Sultana Raisins	Woodland	.474	----------	1.709	----------
Mean	----------	.500	.201	2.301	1.02

In the case of Nos. 4 and 5, the actual weight of fresh fruit corresponding to the quantity of dried fruit taken was not known, but was calculated in accordance with the average percentage of raisins obtained from fresh grapes.

The following averages of eight analyses of European grapes made by Blankenhorn are given for comparison:

Dry substance	14.60 per cent.
Ash in dry substance	3.65 per cent.
Ash in fresh substance	.53 per cent.
Nitrogen in dry substance	1.28 per cent.
Nitrogen in fresh substance	.19 per cent.

The nitrogen is thus about the same in the fresh fruit in both sets of analyses, the European and the California; the per cent of dry substance, however, is 36 per cent higher in the California than in the European, which accounts for the lower per cent of nitrogen shown in the dry substance. This great difference in the dry substance is doubtless due to a higher percentage of sugar in the California grapes, for the amount of ash is about the same in either case.

The following table gives the percentage composition of the several ashes analyzed, together with the average of three analyses of German grapes given by Dr. Emil Wolff. Johnson in his "How Crops Grow," gives 0.88 per cent as the average amount of ash in grapes. I can find no single analysis showing more than 0.84 per cent, while König gives the maximum of twelve analyses as 0.70 per cent, and the average as 0.50 per cent. This agrees very closely with what I have found in California grapes:

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Analyses of Grape Ash.

Sample.	Pure Ash—Per cent.	Potash—Per cent.	Soda—Per cent.	Lime—Per cent.	Magnesia—Per cent.	Peroxid of Iron—Per cent.	Brown Oxid of Manganese—Per cent.	Phosphoric Acid—Per cent.	Sulphuric Acid—Per cent.	Silica—Per cent.	Chlorine—Per cent.	Total	Less Oxygen Due to Chlorine	Total
1. Thompson's Seedless	.513	53.87	8.66	6.33	2.36	*2.73	.16	15.64	2.92	4.63	3.38	100.68	.87	99.81
2. Gros Colman	.452	43.11	2.26	6.03	2.80	2.08	.26	27.18	7.01	7.45	2.40	100.58	.51	100.07
3. Muscat	.658	52.45	8.34	3.64	2.73	1.15	.28	26.57	2.37	2.23	.30	100.06	.06	100.00
4. Muscat	.402	58.99	4.42	4.43	3.88	3.04	.86	14.67	5.03	3.85	1.06	100.23	.23	100.00
5. Sultana	.475	46.33	7.94	4.35	3.44	2.63	.28	22.15	4.06	8.40	.55	100.21	.12	100.09
Mean	.500	50.95	6.32	4.96	3.04	2.73	.36	21.24	4.28	5.31	1.54	.....	.....	.....
Average of 3 German analyses	.500	50.13	1.75	11.89	3.33	.68	.....	21.09	5.62	2.01	2.17	.....	.....	.....

Analysis of Wine Ash.

Mataro	.244	43.37	7.55	8.18	5.54	1.23	.21	19.00	11.26	1.90	1.86	100.10	.08	100.02

*This determination was not made, but the average interpolated.

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Taking the averages of the five California and of the three German analyses, the following table will show the amount of various soil ingredients abstracted from the soil by a crop of five tons of grapes, and comparison with what is abstracted by a crop of 4,800 pounds of wheat hay and of 20 bushels of grain:

Ingredients Abstracted from the Soil.

	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
Five tons of grapes per acre—Average of five California analyses	50.00	25.48	10.62	12.60
Five tons of grapes per acre—Average of three German analyses	50.00	25.07	10.50	17.00
Wheat hay (Johnson)—4,800 pounds per acre	246.00	43.92	19.80	42.00
Wheat (Johnson)—20 bushels per acre	24.00	7.85	11.90	24.00
Wine (Mataro, from Santa Clara Co.)—800 gallons per acre	15.37	6.67	2.39	.64

Thus it is seen that an ordinary crop of grapes is much less exhausting to the soil than a crop of wheat hay; and even if we should obtain a crop of ten tons to the acre the amount of essential soil ingredients abstracted would still be less than with wheat hay, except in the case of potash, an ingredient which is always abundant in soils where such crops are possible. If the grapes are made into wine and the pomace returned to the vineyard the crop is still less exhausting. In this regard, however, the table is somewhat misleading, for it fails to take account of the considerable amount of potash and other salts which are thrown down by the wine in aging (lees and argol), and are seldom returned to the soil. The most striking point of dissimilarity between the California analyses and the German is the high percentage of soda and the low percentage of lime in the former as compared with the latter. This is easily accounted for by the difference of soil, all the California grapes, with one exception, having been grown in the rich interior valleys, where the soils are so abundantly supplied with potash and soda that the vines take up these substances instead of lime. The exception, No. 2, was grown in the Coast Range, on a soil which, in all probability, approaches more nearly in character that on which the German grapes were grown, and here the dissimilarity between the European and the California analyses is much less marked.

The percentage of phosphoric acid agrees almost exactly with that obtained by the German analysts, if we only compare the means. The variations between the different grapes in the matter of this ingredient are, however, very remarkable. The proportion ranges from 14.7 per cent in the case of the Muscat from Woodland to 27.2 per cent in the case of the Gros Colman from Paso Robles. What the cause of this variation is, the number of analyses is insufficient to show. Apparently it depends neither on variety of grape nor locality of production; the Muscat from Tulare and the Sultana from Woodland are well supplied with phosphoric acid, while the Muscat from Woodland and the Thompson's Seedless (a close relative of the Sultana) from Tulare are in comparison but illy supplied with this substance. The difference between maximum and minimum is about as 100 to 52. European

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analyses show even greater divergences. An analysis of Riesling by A. Hilger shows 27 per cent of phosphoric acid, while one of Silvaner by J. Moritz shows only 10.5 per cent—a difference of 100 to 39.

Though Maumené seems to have proved to his own satisfaction that the application of fertilizers (with the possible exception of potash) to soils devoted to grape culture is quite unnecessary, experience seems to have proved otherwise. The manuring of vineyards is a recognized and almost universal practice in Europe. Many of the most renowned European vineyards are fertilized with the manure from cattle farms, which are maintained principally for that purpose. In our own vineyards doubtless the same mode of renovating the soil would be the most beneficial, though it will probably be long, except in the oldest vineyards, before extensive or heavy fertilizing will be necessary, especially where all the pomace and the ashes of the canes are carefully returned to the soil.* In the rich valley soils the case is different. Here there is an abundance of potash, even for the larger crops obtained, but the phosphoric acid is generally scanty, and the drain on this ingredient proportionately great. Here therefore the first need will doubtless be a phosphatic manure.

The belief which has existed that the application of manure to vineyards was liable to communicate bad odors to the wine is erroneous, unless the manure should be applied so late that the grapes could come into contact with it. Provided that the manuring is done before plowing, and the fertilizer thus thoroughly incorporated with the soil before the appearance of the grapes, there is absolutely no danger that the wine will acquire bad odors from this source. The chief danger to the quality of the wine from injudicious fertilizing is that by applying highly nitrogenous manures the vegetation of the vine may be so stimulated as to give a large quantity of watery and insipid grapes, which are incapable of producing a wine of high quality.

COMPARISON OF METHODS OF SUGAR ANALYSIS AS APPLIED TO GRAPE JUICE (MUSTS).

By Geo. E. Colby.

The determinations of sugar (of which the results are tabulated below) were made simply to determine how far the results obtained by the *volumetric* method, used here already some thousands of times, are comparable with those afforded by some of the *gravimetric* methods. In an Experiment Station like this where so many sugar determinations must be made, it is necessary to use an expeditious as well as an exact method, thus forcing us to reject the gravimetric methods for all ordinary work. Moreover, it sometimes occurs that we are called upon to certify to the amount of sugar in commercial products (for instance condensed must) which may appear in other markets. The English and German chemists would, we are reliably informed, use one or more of the gravimetric methods for determining the sugar in these materials.

*The acidity of the pomace should be neutralized by lime before it is applied to the soil. Many attempts have been made to treat the canes in some manner which would more completely utilize their fertilizing properties than by burning them, but the schemes advocated are all more or less expensive, tedious, and in general unsuccessful.

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(*a*) *Volumetric*, or method used here for sugar determination in juices of fruits, in wines, etc. This method is printed in U. S. Department of Agriculture, Division of Chemistry, Bulletin 35, page 207, and is practically Soxhlet's volumetric method, although modified here so as not to use so much copper solution. Fehling's solution used is made as described in the above-named report, page 106. The amount of juice taken, addition of lead acetate, and dilutions to reduce to 1 per cent sugar solution, are as follows for grape juice: 150 cc. juice plus 20 cc. basic lead acetate, filter; to 50 cc. filtrate from above mixture add 50 cc. of either a 10 per cent sodium carbonate or 50 cc. fresh SO_2 (sulphurous acid) solution for the removal of lead; then dilute filtrate from lead, in all ordinary musts, *ten* times, and titrate this last solution exactly against 10 cc. of Fehling's solution. The percentage of sugar in juice is then easily calculated from the above data, counting 10 cc. Fehling's solution as worth 0.05 gram sugar (cane sugar has not been found in juices of grapes here when tested for).

(*b*) *Gravimetric Methods.*—Both the methods, *reduction of cuprous oxid*, and *electrolytic*, are given in report named above on pages 207–212. The juices used in this work were measured. The results, given below, speak for themselves.

Results Obtained by Different Methods of Analysis.

Number and Name of Sample.	Solid Contents of Juice, by Spindle—Per cent.	Volumetric Method.	Gravimetric Methods.	
		Fehling's Solution—Per cent.	Reduction of Cuprous Oxid—Per cent.	Electrolytic—Per cent.
2021. Black Ferara	26.60	25.25	25.57	25.28
2024. Black Morocco	21.50	19.54	19.72	19.36
2023. Almeria	24.35	22.67	22.87	22.75

FRUIT AND FRUIT SOILS IN THE ARID AND HUMID REGIONS.*

By E. W. Hilgard.

I desire to bring before this audience some points relating to the researches of the Experiment Station, and particularly the differences we have found in comparing European and Eastern results with ours.

It is so often attempted to apply the data obtained and the practice prevailing in humid climates to our conditions, that it seems desirable to outline distinctly some of the main differences already established between the arid and humid regions as regards the natural conditions of agriculture and horticulture and the products obtained.

"Arid" means an irrigation country with scanty rainfall, and no summer rains. When we review the list of such countries we find among them those having developed the oldest civilizations—Egypt, Syria, Persia, India; in America the Mexican plateau, Peru, and Chili. Why did those people choose lands apparently so uninviting, requiring laborious irrigation, instead of going where nature provides an abundant rainfall?

*Lecture delivered at the Horticultural Convention held at Los Angeles, 1893.

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Average Composition of Soil.—The following table contains, I think, some of the fundamental facts that have determined their choice. This table shows the generalized results of about eight hundred analyses of soils of the southern and western United States, selected with a special view to their representative character; all samples having been taken in like manner, and all analyses made by the same method. It is by far the largest series of such analyses that has ever been made in a uniform manner and from so large an area; it therefore offers the first opportunity for comparison between the soils of widely different climatic regions, on a sufficiently extensive basis to insure results independent of local accidents. It is perhaps necessary to remark here that no comparison is possible between soil analyses made by different methods. You can get from one and the same soil a score of different results by varying the method.

Let us see wherein the differences between the soils of the arid and humid regions chiefly consist.

	Humid Region. Average of 466 Soils.		Arid Region. Average of 318 Soils.	
Insoluble matter	84.031	87.687	70.565	76.135
Soluble silica	4.212		7.266	
Potash		.216		.729
Soda		.091		.364
Lime		.108		1.362
Magnesia		.225		1.411
Br. oxid of manganese		.133		.059
Peroxid of iron		3.131		5.722
Alumina		4.296		7.888
Phosphoric acid		.113		.117
Sulphuric acid		.052		.041
Carbonic acid				1.316
Water and organic matter		3.644		4.945
		100.178		99.998
Humus		2.530		
Humus per cent		2.700		.750
Nitrogen per cent in humus		5.450		15.870
Nitrogen per cent in soils		.122		.101
Hygroscopic moisture		4.650		6.231
Absorbed at		18.5°C.		15°C.

Considering, for the present purpose, only the mainly important ingredients, namely, those which we have to replace by the use of fertilizers, we see that in the case of *potash*, the soils of the arid region exceed those of the humid in the proportion of more than three to one; and nearly the same is true of *soda*.

As regards *lime*, we see that the proportion is a much higher one—nearly fifteen in the arid to one in the humid region. In the case of *magnesia*, nearly five and a half to one. As to the condition of these substances—their relative availability as plant-food to be drawn upon by crops—the item above, "soluble silica," shows that their easily decomposable compounds are more abundant in the arid soils to the extent of at least one half more.

As regards one of the most important ingredients—*phosphoric acid*—the table shows that there is no material difference on the average; a result to be expected on chemical grounds.

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Concerning humus, which among other points involves the supply of nitrogen, the most costly of all to supply in fertilizers, the table would seem to show a difference very much against the arid soils. But as will be seen, this difference is more apparent than real.

The cause of the main differences is simply that in the arid region the rainfall is insufficient to wash the soluble portions of the soil through into the country drainage; while in the humid region the soil is constantly being leached by the rains, especially by those of summer. Thus both potash and soda—very soluble in water, as you know—are left in the soils of California partly in the soluble form, partly in that of new combinations, from which the roots of plants can readily absorb them. The easily soluble parts we call "alkali." In sea-water we have the most general outcome of the leaching of the land; but before these leachings reach the sea they are so far changed in their nature that most of the lime and potash remains behind, while most of the soda passes forward and forms "sea-salt."

We find, then, that the prominent difference between the soils of the humid and arid regions consists, throughout, in a very large average excess of lime, and a smaller but still very decided excess of potash in those of the arid region as compared with the humid.

Lime.—The excess of lime is so large as to place all the soils of the arid regions in the class of limy or calcareous soils. Now, in the humid regions of the East and of Europe, it is an adage that "a limestone country is a rich country." As all arid soils are virtually limestone soils, it follows that "arid countries are rich countries." And right here seems to be the explanation of the preference the ancient nations had for arid or irrigation countries.

Liming, of course, can do no good to land that is already limy to the extent to which lime is useful in soils. This has been the experience of California, apart from exceptional cases mostly of unusually heavy soils. Of course, marls containing other useful substances (*e. g.*, phosphoric acid) may nevertheless be good fertilizers.

Potash.—What is true of lime is also, in a great measure, true of potash. It is true that the excess of potash in the arid soils is not as great as in the case of lime, but the fact that dissolved potash is all but universally present in the alkali salts that we find everywhere, whether in the low grounds in the form of alkali spots or crusts, or in the waters of the streams that come from and leach out the uplands, admonish us that the need of artificial fertilization with potash must be the exception, and the contrary the rule. In proof of the facts alleged, I call attention to the table (see folder, p. 135), which shows the composition of the alkali salts at various points in this State, and one at least out of many I have examined from the State of Washington.

You perceive that a very considerable percentage of all these "alkalies" is potash; and in soils impregnated with them the aggregate amount is many times larger than you would dream of introducing in the form of potash salts as fertilizers. To do so would evidently be to "carry coal to Newcastle." And so long as the alkali salts are being washed out of the uplands by the winter rains—and that is just where the alkali comes from—it is not probable that the uplands themselves will need replenishment of their potash until they shall have been cropped heavily for some time. But that is question of fact, easily tested by an experimental application of potash. Such tests made at our stations have in all but

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one case proved the inefficacy of potash fertilization; that one case was foreseen by the fact that the analysis of the soil showed it to be very poor in potash. But such cases seem to be quite rare, as is shown by the general average for California soils, given in the table. In regions long settled and heavily cropped, of course potash will gradually become a needful and efficient fertilizer.

Phosphoric Acid.—Phosphoric acid is not, as the table shows, among the substances favored by aridity; its supply is independent of climatic causes on account of its insolubility in the soil. The detailed table also shows that California soils are rather behind in the average contents of this substance; hence phosphates have proved preëminently effective in the great majority of cases—not of course in those in which alkali, like some that is shown in this small table, impregnates the soil.

Nitrogen.—As regards the other important element of plant-food, nitrogen, the small table shows that in some cases—in most alkali soils—it is exceedingly abundant in the soil in the form of nitrates; which as is well known form rapidly in arid climates, since from these our supply of commercial nitrates comes. Chili and Nevada are in point. But these nitrates have the disagreeble property of being very easily washed out of the soil by rains or irrigation; therefore the uplands may require fertilization with nitrogenous manures even though the alkali in the lowlands may contain abundance. There are, however, some peculiar points still under investigation, tending to show that there are compensating agencies which, even in the uplands, render the nitrogen-supply relatively easy under arid conditions. Briefly stated, the fact seems to be that the humus of arid soils is so much richer in nitrogen than in the humid region, that the average amount in the soils is nearly the same in both regions; and that it is more readily available to plants in the arid climates.

COMPOSITION OF CALIFORNIA FRUITS.

So much for the *soils* with which California fruit-growers have to deal, and which, as you perceive, are quite materially different in character from those of the regions of summer rains. That the same is true in a measure also of the *fruits* grown upon them, can be perceived by the palate alone, when you have them at hand for comparison. But as this is not often feasible, and as tastes will differ, we have gone to a great deal of labor in investigating the composition of California fruits. I may say of this work, as of that on soils, that for the fruits examined we have now at our command a larger series of fruit analyses than are on record from all the countries of Europe combined. Here is a tabular statement of the analyses made thus far:

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Summary of Number of Fruit Analyses Made at Agricultural Experiment Station, 1880 to 1893.

	No. of Samples Examined to December, 1892.		Crops of—
Citrus Fruits (92 samples)—			
Oranges	130		
Lemons	45		
Total		175	1891, 1892, 1893.
Stone Fruits—			
Prunes	36		1891 and 1892.
Apricots	14		
Plums	3		
Peaches	2		
Nectarines	1		
Total stone fruits		56	
Olives		26	
Figs		41	
Grapes (Musts)		2,136	1880 to 1893.
Wine		1,500	1880 to 1893.
Total		3,934	

This multiplicity of analyses enables us to give reliable averages for a number of fruits of which only a few analyses are reported from Europe. So far as these enable us to make comparisons, there are very serious differences in the composition of many of the fruits, both as regards the proximate ingredients (such as sugar, acid, albuminoids or flesh-forming ingredients, etc.), and with respect to the ash composition, which bears particularly upon the draft they make upon the soil. Here are a few data referring to the first class of ingredients, which bear specially upon the taste and nutritive value of the several fruits:

Percentages of Sugar and Acid.

(From Bulletins 97 and 101.)

No. of Analyses.	Fruits.	California.				Europe.
		Juice.		Flesh.	Whole Fruit.	Sugar.
		Acid—Per cent.	Sugar—Per cent.			
11	Apricots	.68	13.31	11.93	11.10	10.0
23	Prunes	.40	20.00	16.11	15.35	6.2
13	French prunes	.31	23.69	19.70	18.53	.....
3	Plums	.48	17.97	13.25	12.89	3.6—7.0
2	Peaches (from Shasta and Butte Counties)	.24	17.00	13.40	12.50	2.0—4.5
1	Nectarine	.62	17.17	15.13	14.11	.....
	Grapes from various localities	.50	24.00	23.00	20.70	14.40
80	Oranges from various localities	1.28	10.68	7.12	5.40	4.60
2	Figs (White Adriatic) from Kern and Fresno Counties	.15	23.90	.....	19.20	11.50

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Average Percentages of Albuminoids.

No. of Analyses	Fruits.	In Whole Fruit—Total.	In the Fresh Flesh, or Edible Portion.	In Fresh Pits or Rind.
			Calculated upon Whole Fresh Fruit.	
	ORANGES.			
35	California	1.140	.760	.380
....	European (Sicilian)	1.780	....	....
	APRICOTS.			
11	California	1.250	1.088	.162
....	European	.490	....	....
	PRUNES.			
20	California	1.012	.837	.175
....	European	.780	....	....
	PLUMS.			
3	California	1.130	1.000	.130
....	European	.400	....	....
	APPLES AND PEARS.			
....	European	.375	....	....
	FIGS.			
2	California (White Adriatic)	1.500	(1.50)	....
....	European (Smyrna)	1.420	....	....
....	NECTARINES	.731	.625	.106

Comparison of Proximate Ingredients.—Thus we have in the case of the apricot, 12 per cent of sugar against 10 in the European fruit; in the case of prunes, 16 against 6 and a small fraction; in plums, 13½ against about 5; peaches, 13 against 4½; grapes, 23 against 14½; oranges, 7.12 against 4.6; figs, 19 against 11½. In most of these cases there is a corresponding excess of acid in the European fruits. That such considerable differences must influence materially the palatableness of the product, as well as its digestibility and nutritive value, is manifest.

But no less serious, and perhaps more directly affecting the nutritive value, are the differences in the contents of the flesh-forming ingredients—the "albuminoids." Here we have in the case of the apricot a proportion of 5 for the California product against 2 in the European; in the prune, 5 to 4; in plums, 11 against 4. For figs also the difference is slightly in favor of the California product; while singularly enough, in the case of oranges the difference is the other way, in the proportion of about 11 to 18.

Thus, aside from the orange, all of our fruits thus far examined exceed considerably the European fruit, both in sugar and flesh-forming substances, greatly to the advantage of their nutritive value. For the orange, while the sugar is also in excess with us, the flesh-forming ingredients are relatively less.

It will thus be seen that both as regards the contents of sugar, acid, and albuminoids, there are differences which in some cases amount to over 50 per cent of the figures found for California fruits.

Comparison of Ash Composition.—Differences nearly as great occur in the ash composition.

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Soil Ingredients Extracted by Different Fruit Crops.

Fruits.	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
GRAPES.				
European—				
In each 1,000 pounds	8.8	5.00	1.52	1.70
	4.90			
APRICOTS.				
European—				
In each 1,000 pounds				.86
Crop of 30,000 pounds	147.00			25.80
California—				
In each 1,000 pounds	4.91	2.90	.64	1.94
Crop of 30,000 pounds	147.30	87.00	19.20	59.20
PRUNES.				
European—				
In each 1,000 pounds	6.3	3.73	.95	1.22
Crop of 30,000 pounds	189.00	111.90	28.53	36.60
California—				
In each 1,000 pounds	4.86	3.10	.68	1.62
Crop of 30,000 pounds	145.80	93.00	20.40	48.60
PLUMS.				
In each 1,000 pounds	5.35			1.81
ORANGES.				
European—				
In each 1,000 pounds	6.07	2.78	.67	2.69
Crop of 20,000 pounds	121.40	55.60	13.40	53.80
California—				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60
FIGS.				
European—				
In each 1,000 pounds	8.00	2.27	.10	2.27
Crop of 15,000 pounds	120.00	34.05	1.50	34.05
California (White Adriatic)—				
In each 1,000 pounds	7.81	4.69	.86	2.38
Crop of 15,000 pounds	117.15	70.45	12.90	35.70

Thus, as regards *potash*, we find in California prunes only 93 pounds of potash per acre for a 30,000-pound crop, while for Europe the figure is 112. For oranges the corresponding figures (20,000 pounds per acre) are 86 against 121; for figs, the figures are nearly identical. The general result is that the potash is uniformly less in California fruits than in the European.

For *phosphoric acid* we find some very striking differences, amounting in the case of the fig to a proportion of nearly 9 in the California to 1 in the European. For oranges the difference in the same direction is as 13 to (nearly) 11; in prunes, as 95 to 68. We find, then, as regards phosphoric acid, that California fruits draw more heavily upon the soil than do European ones. Since (as I have shown) California soils are rather deficient in that substance, this is a significant indication for the horticulturist.

But in this respect even greater significance attaches to the *nitrogen* contents of these fruits, which, as already shown, is considerably greater in California fruits in all but the orange. Thus an average crop of California apricots takes out of the soil nearly 60 pounds of nitrogen against about 25 in the European; prunes, 49 pounds against 37 in Europe. In figs there is only a slight difference; in the case of oranges, the California takes only 37 pounds against 54 in Europe.

European Data and Rules Not Always Applicable to California.—Such differences as these should warn us against taking for granted that in our climate and in our soils the data and rules transmitted to us from

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Europe and from the East are applicable; the more as we have our own data in a much more complete shape than are, thus far, those coming to us from the outside. Our growers as well as our fertilizer manufacturers must take note that what is true for the humid climates, from which most of our data for these matters are derived, does not necessarily hold good in arid climates. By reason of their comparative remoteness from the centers of scientific investigation, the products and soils of the arid regions have until now received but very little attention; and what has been done outside of this State has been mostly done in such a scattering and unsystematic manner as to convey scarcely any data for definite comparison. I am therefore justified in calling the attention of farmers, and especially of fruit-growers, to the fact that Eastern precedents will not serve them in these matters; and that when fertilizers are offered them upon the basis of Eastern or European data they should consult first the facts elicited for them by the State Experiment Station, in order to see that their money is spent to the best advantage. Much remains to be done, but what has been done is at least worthy of their close attention.

The reports and bulletins of the Experiment Station are sent free to any citizen of California making application therefor.

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II.

REPORTS

ON

CULTURE WORK AT THE EXPERIMENT STATIONS.

A. *Central Station;* Alameda County.
B. *Foothill Station;* Amador County.
C. *Southern Coast Range Station;* San Luis Obispo County.
D. *San Joaquin Valley Station;* Tulare County.
E. *Southern California Station;* Los Angeles County.
F. *Forestry Stations;* Chico and Santa Monica.

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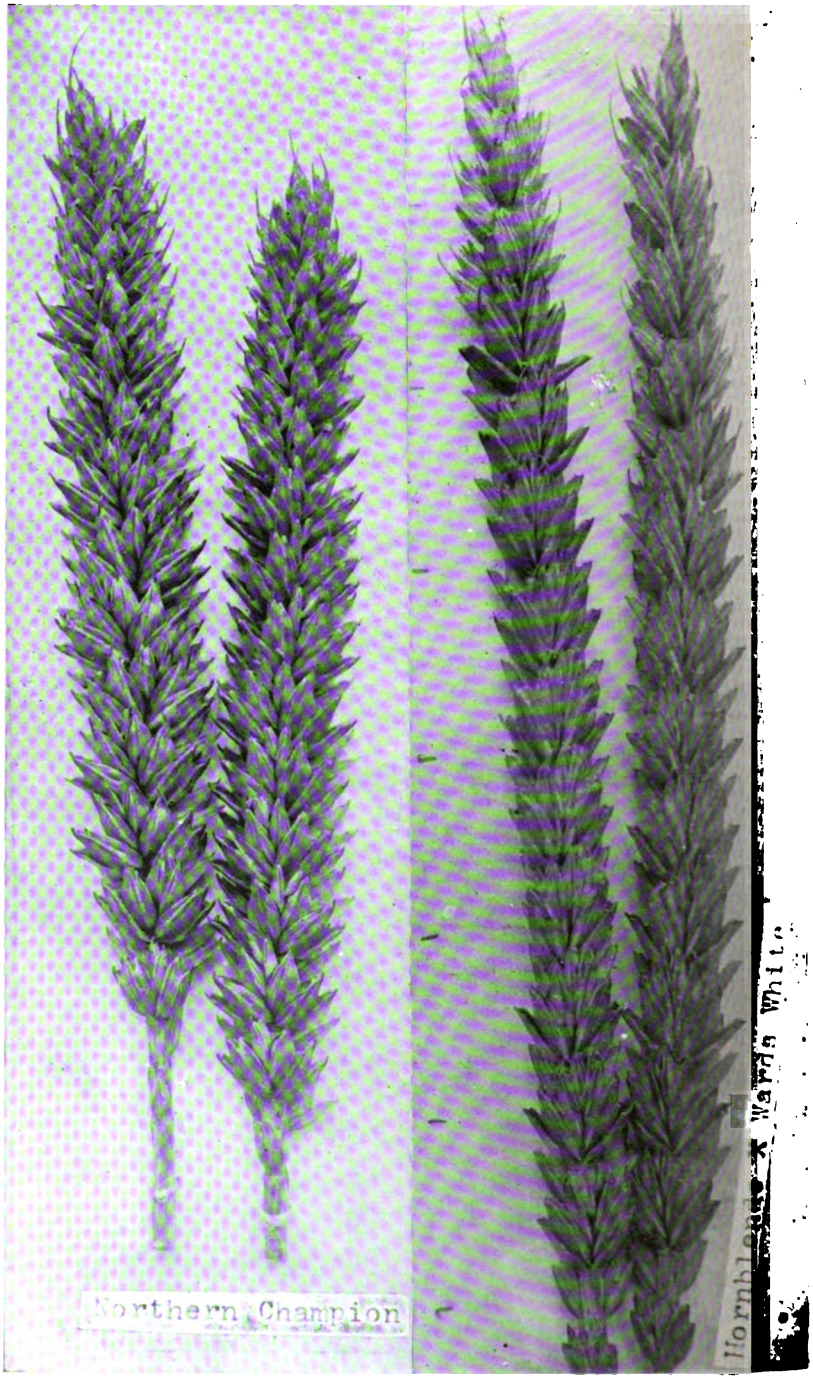

TWO NEW WHEATS NOW ON TRIAL AT CENTRAL STATION.

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REPORTS ON CULTURE WORK AT THE SEVERAL EXPERIMENT STATIONS.

A. CENTRAL EXPERIMENT STATION.

Berkeley, Alameda County.

OUTLINE OF OPERATIONS UPON THE GROUNDS OF THE CENTRAL STATION.

By EDWARD J. WICKSON.

Every effort has been put forth during the past year to accomplish as much as possible with the reduced amount of money apportioned to this department. Increased public interest in the outdoor features of the work at Berkeley has naturally stimulated us to extension of cultures. The requirements of the outlying stations in the way of materials for planting has brought upon the Central Station an amount of propagation far greater and more diverse than was ever undertaken before. Our new efforts seemed to make it necessary that we should have a more liberal allowance of funds for labor at this Station, and certainly more money could have been well expended; in order to meet the new requirements we have been obliged to forego many desirable improvements, and defer items of equipment which are sorely needed. In fact, we have been obliged to figure very closely to secure maintenance and avoid retrogression. In this connection I desire to make special mention of the services of Capt. Emil Kellner, foreman of the agricultural grounds. His management of the affairs intrusted to him is to be largely credited with the efficient and economical use of labor and material which has been secured.

Cereal and Forage Plant Collections for Exhibition.—A full illustration of the efforts of the Station in the collection of varieties of cereals and forage plants was made at the Columbian Exposition and at the Midwinter Fair, as mentioned in the account of these exhibitions in another portion of this report. To secure the material, the full collections were freshly grown; fertilizers were used. The season proved favorable, and very fine specimens were secured. The growth and assortment of material, packing up, and labeling required much time, and still must be considered well employed, for the collections as shown at these great exhibitions won wide commendation, and brought this feature of the work of the Station to the attention of many people hitherto unaware of it.

Records were kept of observations on the growth of the different cereals, which in the main agreed with the data published on pages 138 to 144 of our Report of 1891–2.

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The cereal collection has been largely increased during the last two years, and distribution has been made to a limited extent, from which reports are expected in time for the next report from the Station. An engraving given herewith shows two of the most promising varieties: The Northern Champion and a cross-bred wheat—Hornblende x Ward's White—the latter being one of a series of hybrids originated by William Farrer, of New South Wales, and sent to this Station for trial. Just now, interest in improved and more productive wheat varieties seems to be increasing in this State, as noted elsewhere.

Propagation for Distribution and for Planting at Outlying Stations.—In another part of this report an outline is given of the work of distribution of plants, seeds, cuttings, and scions to voluntary experimenters throughout the State. The extent of the propagation required to furnish materials for this distribution, and to supply also stock for planting at the six outlying Stations, made it necessary to enlarge our propagating grounds. This was done by establishing a new nursery in the northwest corner of the agricultural grounds. The land was deeply and thoroughly worked, properly laid off, and furnished with facilities for irrigation. Upon this ground large collections of Persian and Italian grape varieties have been propagated. It is intended to have always ready on this ground budding and grafting stocks suitable for all kinds of fruits of which we are now receiving buds and scions from originators in different parts of the world.

The Garden of Economic Plants.—This interesting and popular portion of the agricultural grounds has been maintained, in the main, upon lines previously followed. There has been, however, some change in the allotment of the ground. Plants which have been grown long enough to demonstrate their characteristics and adaptations have been reduced to small specimen plots and larger space given to newer plants. The plots devoted to grasses and forage plants have been largely resown. The annexes to the garden planted two years ago are now in very satisfactory condition. The one given to the collection of wild grapes from different parts of the world, grown on trellises, as required by their habit of growth, is now one of the most attractive features of the grounds. Much re-labeling has been done in the garden during the last year. It also became necessary, through the washing of the creek bank, to put in a temporary restraining wall, which was done by driving posts at the base of the bank, interweaving willow branches, forming a sort of heavy wickerwork. Behind this the space was filled with good soil, in which the willow branches rooted readily. This growth promises to bind the whole structure firmly to the bank and to remove the menace to some of the most valuable trees along the top of the bank, at least for the present. In this connection it must be noted that an embarrassment and trouble which has not been grievous hitherto is now becoming serious and some effective steps must be taken for its reduction. Both in the Economic Garden and in other parts of the grounds we are experiencing considerable losses through plant thieves. The growth of Berkeley as a city, and the multiplication of methods of quick transit, are making the University domain more and more a public resort. Unfortunately, many dishonest persons are now appearing, who do not hesitate to break off parts of plants or even pluck them out by the roots if they are at all attractive or novel. We have been obliged to plant out many of our newest things without labels, because the discriminating

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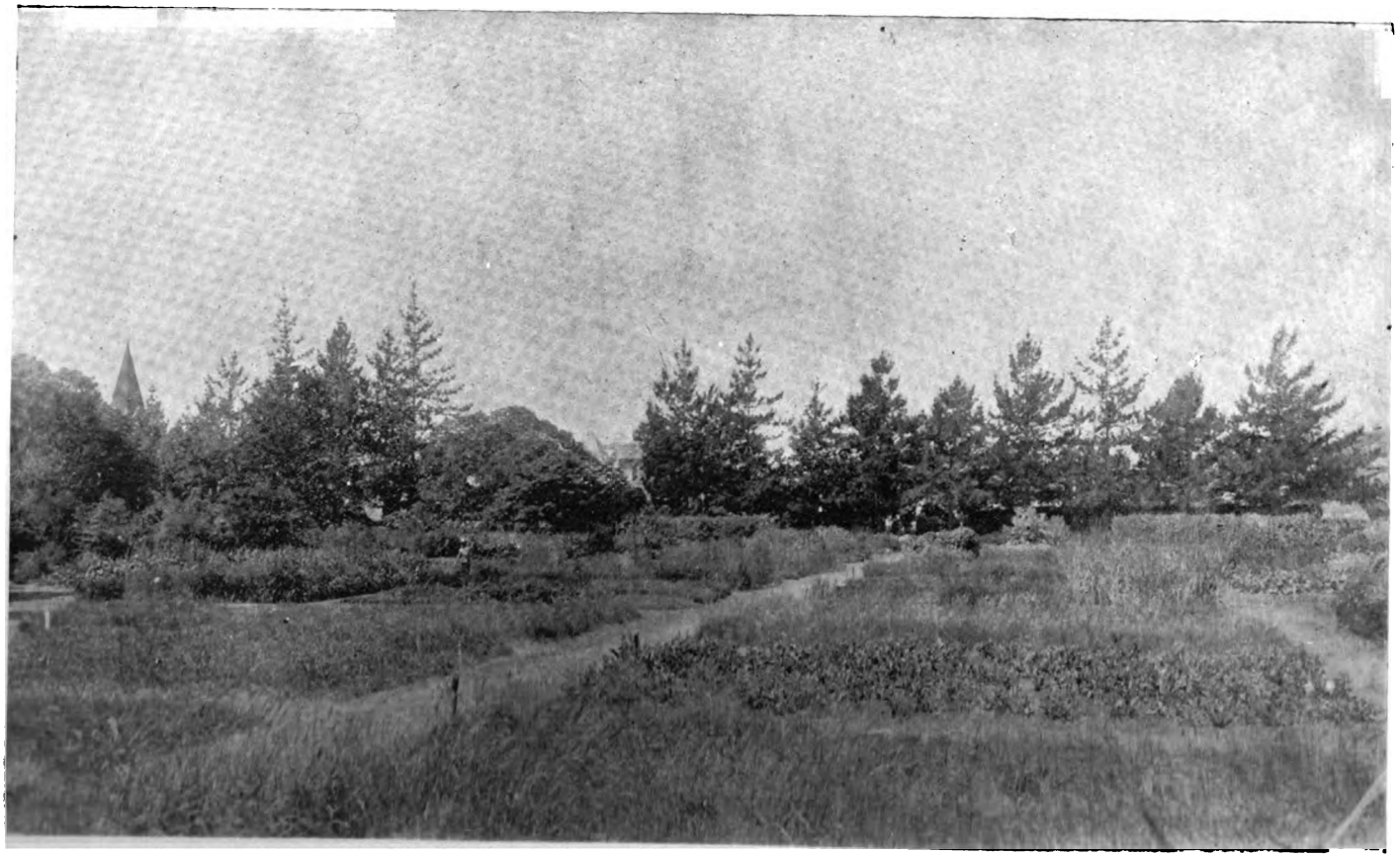

View, looking west, in the GARDEN OF ECONOMIC PLANTS, showing style of culture plots

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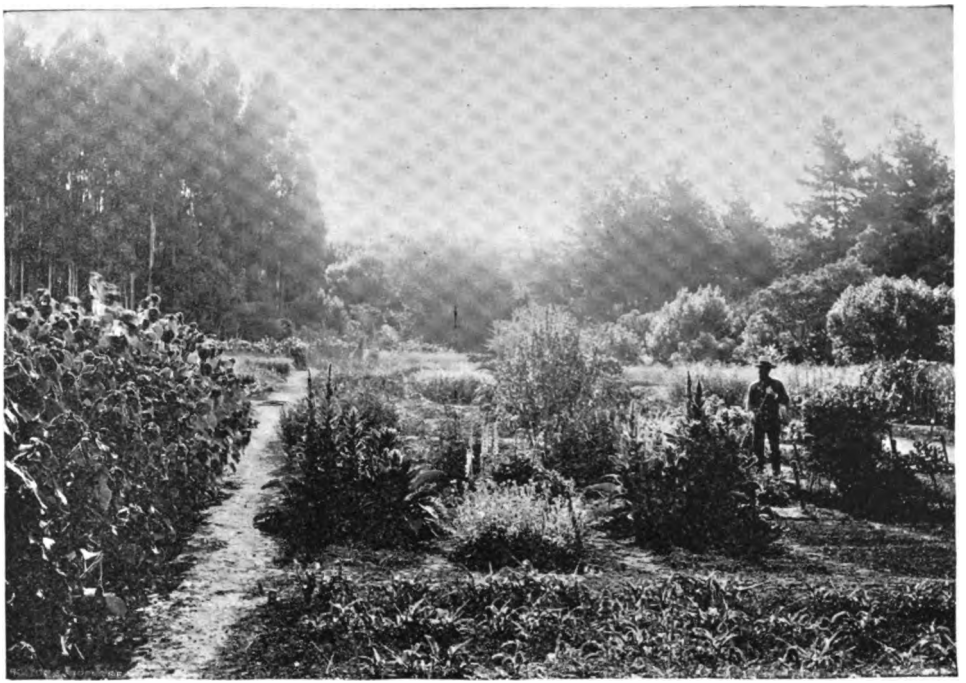

GARDEN OF ECONOMIC PLANTS, CENTRAL STATION. View from the west.

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thieves seem to know well what is most desirable. It has also been necessary to keep watchmen employed on Sundays and holidays during a great part of the growing season, but the thieves watch the watchmen and take advantage of every moment of temporary absence. As it would not be fair to the general public to exclude them from the experiment grounds, and as their exclusion would seriously impair our efforts, which naturally court public interest, it seems likely that more efficient and extended police patrol must be provided and vigorous prosecution of trespassers adopted. Possibly in this way dishonest persons may be made to show greater respect for the public interest and public property.

A partial view of the Garden of Economic Plants, showing a number of culture plots, is given herewith in an engraving from a photograph by Dr. Loughridge. Another is from a plate kindly loaned by the *Overland Monthly*.

Field and Orchard.—These parts of the grounds have had due attention during the year. Some useless trees have been removed and many new varieties of different fruits have been planted. A large amount of stable manure has been secured without cost, except that of hauling with our own team, and it has been used to good advantage. The value of such dressing to old trees in such lean and shallow soil as we have in Berkeley is very apparent. The treatment of the stable manure gathered from various sources has been to hold it for several months in large piles, applying water enough to keep the mass moist, and using dry earth or gypsum as a cover to render the fermentation inoffensive and to retain the matters which might otherwise be lost in the atmosphere. The application of this manure to the field on which oat hay has been grown for several years produced a notable improvement in this year's yield, although the season was unfavorable.

TWIG-BUDDING AND GRAFTING THE OLIVE.

The popularity of the olive clearly appears in the public interest taken in the introduction and propagation which we have been carrying on for several years, and of which preliminary mention has been made in earlier reports. Captain Kellner had made special effort to inform himself on these varieties and the feasibility of working them upon stocks of inferior varieties which many growers wish to transform. Of his experience in budding he furnishes the following note:

I find twig-budding to be the best manner of changing seedling or inferior olive varieties to good ones. The operation can be performed at any time of the year when the bark will peel and the twig-buds are in proper condition. If done late in the summer the buds lie dormant until spring. Good results can be obtained by budding in the spring, as the operation can be performed to a better advantage, and the buds will make growth the first summer. When the operation is performed on large trees, the top should be only partly removed until the twig-bud has made some growth, when the whole limb may be removed, leaving say eight or ten inches to tie the young shoot to. After a year remove the whole limb, make a smooth cut and use some grafting compound to heal the wound. The bud or twig-bud to be used should be hard, that is the young shoot should be matured. The bud should be cut deep into the wood, the leaves should be partly cut off, then with the sharp point of the budding-knife the greatest part of the wood should be removed. After removing the wood from the bud, place the same in the T incision, as done in common budding, tying with cotton twine or "raffia," and afterwards with a strip of waxed cloth to keep out the air and moisture.

Grafting can be done also in the spring—March and April. The scions to be used in grafting should be cut during the dormant state of the olive tree in winter, and heeled-in in sand to keep them alive. In using the wedge graft care should be taken not to split the limb to be grafted further than necessary for fitting the scion. Grafting by approach has been done at this Station to secure trees for our outlying stations. This will show the character of the fruit sooner than can be had with trees raised from cut-

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tings. A frame was built around the varieties to be used, and seedling olive trees in pots were placed on it. A shoot to be used as a scion was bent down to the seedling, a common whip graft made on this shoot, a corresponding cut made on the seedling; the two are interlocked and tied. The scion is connected with the parent tree, and after the graft has made a growth, it is partly cut off, so as to have the graft sustain itself. By degrees the whole limb is cut off and the tree is ready for transplanting.

THE LOGAN BERRY.

No single fruit has excited more interest among visitors to the Station grounds than the Logan berry. A few plants were donated to the Station by the originator, Judge J. H. Logan, of Santa Cruz, several years ago. Its splendid size, prolific bearing, and notable excellence as a table fruit when thoroughly ripened, convinced us of its unique character and exceptional value as a new fruit. Plants were propagated as far as was possible under the limitations of the habit of the variety, which is to multiply by growth from the tips like the Black Cap class of raspberries, though, of course, layering of the whole cane multiplies the plants. Growth from cuttings is not satisfactory as a rule. The plants were first offered to the public in Bulletin No. 102 of this Station, issued in December, 1893, although it had been privately disseminated previously to a limited extent. The largest grower, Mr. James Waters, of Watsonville, has successfully marketed the fruit for several years, but did not offer the plants for sale until after our announcement. Our description of the fruit attracted much attention at the East, as well as in this State, and we could only supply a small number of those who applied to us for plants.

The Logan berry is an exceedingly robust grower, and has unique foliage and cane growth as well as fruit. All of these are indicated in the accompanying engraving, from a photograph by Dr. Loughridge, of fruit grown upon the Station grounds. The fruit is strikingly large and handsome, and a laden cane is a sight not to be forgotten. The fruit is sometimes an inch and a quarter long, with the shape of a blackberry, and sometimes the hue of a dark-red raspberry. Its flavor is unique and peculiar, and gives to many tastes suggestions of the combination of blackberry and raspberry flavors. So far the vigor of the growth of the plant seems to give it freedom from leaf disease of all kinds. For our coast and valley climates, so far as tried, it shows perfect adaptation. How far it will withstand the heat and drought of the interior or the freezing of wintry climates can only be told by the trial which it is now receiving under almost all conditions.

Concerning the origin of this remarkable fruit we cannot do better than introduce the following account, written by the originator, in his correspondence with this Station, under date of August 12, 1891:

The berry is a cross between the Aughinbaugh blackberry (a wild berry found by a Mr. Aughinbaugh, of Alameda, near the bay at Schutzen Park) and an old raspberry that Id o not know the name of. It is a very common berry here and belongs to the French type of raspberry. The Aughinbaugh stood between a row of the Crandall or Texas Early and the raspberry named. I gathered the seed and planted it in the fall of 1884 in tending to get a cross between the Crandall and Aughinbaugh. I did not think such a thing as a cross between the raspberry and blackberry possible. I have never attempted to do anything with it commercially, but it has borne abundant and regular crops ever since. The berry has been grown from seed several times and the result in every case has been a true redberry. I suppose a thousand seedlings have been grown from this plant, and I have never heard of a single instance of a seedling resembling either the raspberry or the blackberry; they are not all as good as the parent, but they are all true redberries. This shows that the berry has come to stay. That it is an entirely new and distinct berry I have no doubt. It is known and grown all over this county as the Logan berry. (J. H. LOGAN, Santa Cruz.)

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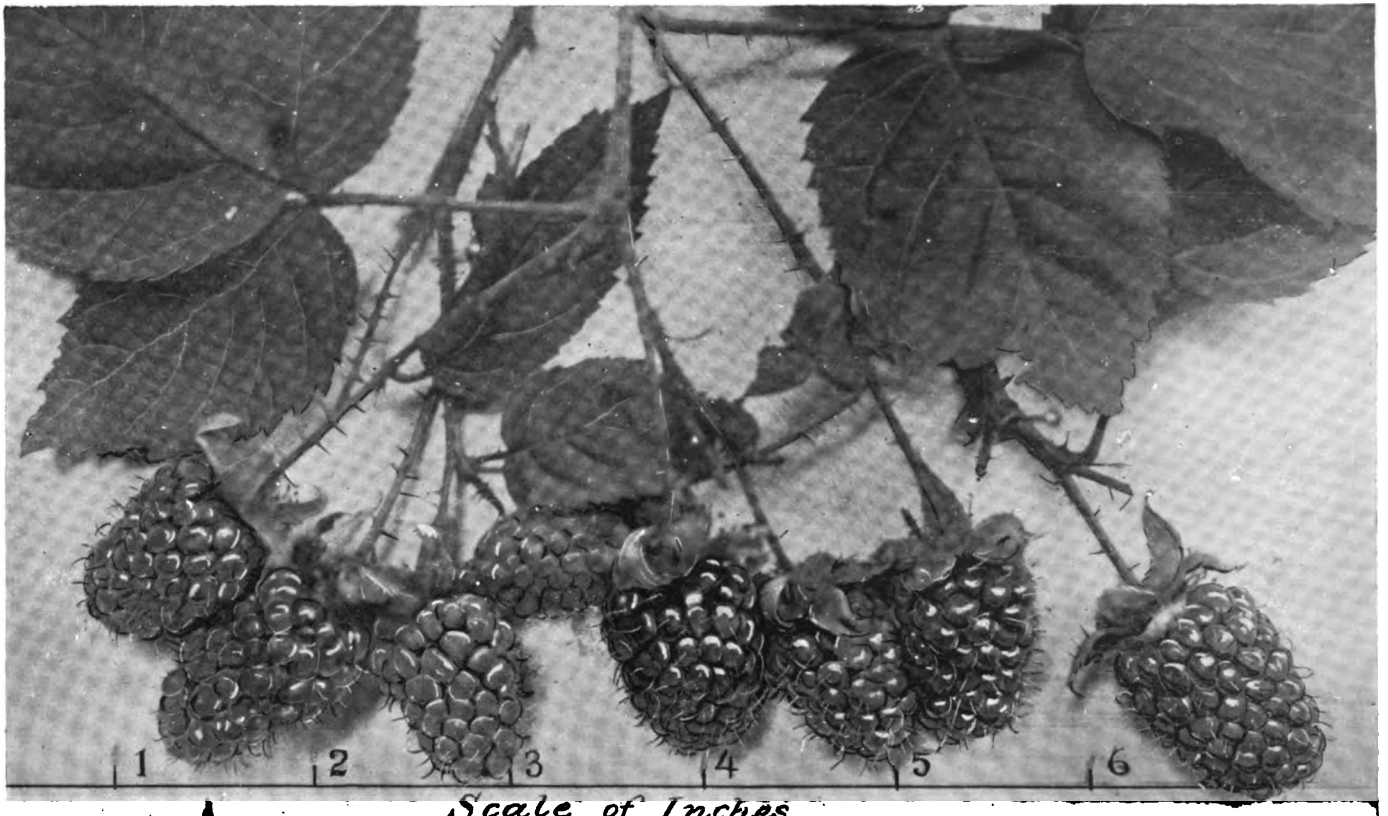

LOGAN BERRY (natural size) grown on the Station grounds Berkeley.

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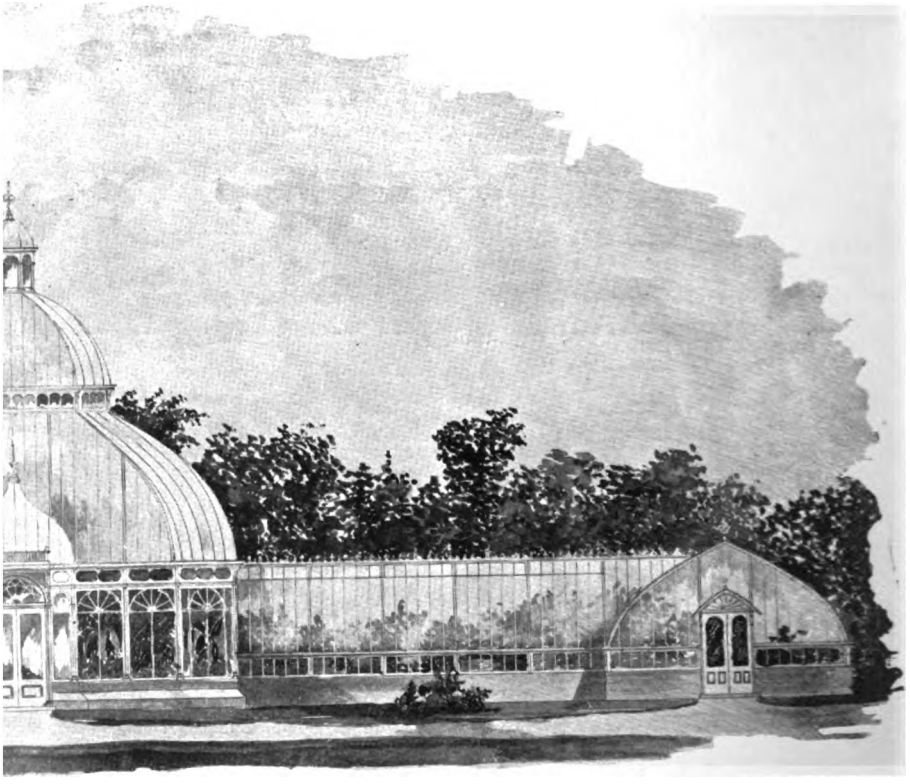
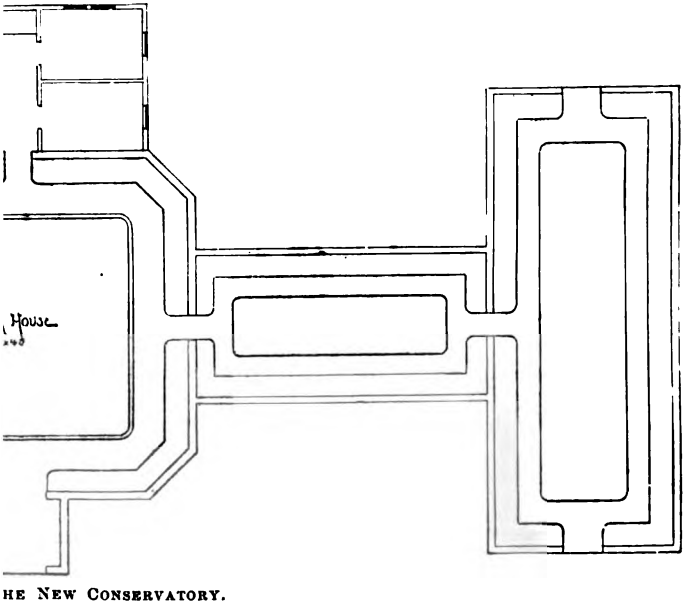


DEPARTMENT OF THE UNIVERSITY OF CALIFORNIA.



HE NEW CONSERVATORY.

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THE NEW PLANT HOUSE.

At this writing (July, 1894) the foundations for the new plant house of the Agricultural Department are being laid. The facilities which this building will afford have long been greatly needed. The old wooden houses which were erected for temporary purposes almost twenty years ago were always too small to meet the demand for propagation, and too low to admit of the growth of even ordinary specimen plants. During the last few years, when our introduction of exotics and multiplication of them for distribution and for planting at outlying stations has so largely increased, the old houses have become painfully inadequate. It is with great satisfaction, therefore, that we report the progress of work on the new plant house, an engraving of which is given herewith. The plant house was designed by Lord & Burnham, of Irvington, N. Y. The materials of the superstructure are iron and glass throughout, no wood being employed except for doors, and cap and sash bars, which come immediately in contact with the glass. The plant benches will be of iron and slate of the most modern style of construction, and the hot water heating apparatus will also be of a pattern approved by recent comparative tests. In these respects we expect that the new range of houses will be a model of this class of structures, and will be an example to those contemplating green-house building.

The new plant house is situated upon the slope between the Students' Observatory and the Botanic Garden. This location is desirable, because of higher temperatures secured by elevation, and it will also bring the building into view from the main portions of the campus and the other buildings of the University. The range of buildings fronts south. The extreme length is a little more than 170 feet, and the greatest depth will be 87 feet. The total interior area will be upwards of 7,000 square feet. The dimensions of the several portions of the range, as shown on the ground plan accompanying, are as follows: Vestibule, 10x12 feet; palm house, or central portion, 45x45 feet, with a clear height of dome of 42 feet; extensions on each side of the palm house, 20x37½ feet, 14 feet high; wings on each end of the range, 25x60 feet, 16 feet high. Thus the main structure consists of five apartments inter-communicating and still isolated so as to admit of the maintenance of different temperatures as required for the different classes of plants. In the rear of the palm house is a building 29x30 feet for office, potting shed, and heating furnaces. It is anticipated that the building will be ready for occupation before the close of the present year. The building and its appurtenances will cost about $13,500.

THE UNIVERSITY BOTANIC GARDEN.

By J. Burtt Davy, of the Department of Botany.

The arrangement of the paths in the Botanic Garden, as detailed on the plan given in the 1891–2 Report, p. 167, having proved inconvenient, because somewhat obstructing ready access to the various flower-beds, it was considered advisable to make the necessary alterations before the rapid growth of trees and shrubs rendered such a course impracticable without much sacrifice of valuable material. This work

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has been carried out during the past winter and spring, under the direction of Mr. Ivar Tidestrom, Student-Assistant in the Department of Botany, upon a design of his own preparation. The consequent transplanting, though undertaken rather late in the season, has on the whole proved very successful.

New ground has been broken between the path leading to the observatory and that leading to the new Mechanics Building, but the arrival of the dry season made it advisable to desist from planting until the fall rains. It is expected that the remaining unbroken ground will be brought under cultivation during the coming winter.

A rockery for the cultivation of ferns and other plants needing cool shade and constant moisture is being formed under the shade of trees at the southwest corner of the garden. The nucleus of a collection of Californian ferns has already been planted here, and the probable success of this experiment in the culture of these attractive plants in a region which is normally too dry for most of the species, seems assured by the supply of water laid on to the lower portion of the garden last May. Mr. Henry Melde, of Eureka, Humboldt County, has generously sent ten fine roots of the Deer Fern (*Lomaria spicant*) which will be planted on the rockery as soon as it is ready to receive them.

Owing to the depredation of visitors it has been found necessary to fence-in about half an acre of the best ground, where the rarer and more beautiful flowers can be propagated and experimented upon without interference. The mania for stealing roots as well as flowers seems to be seriously on the increase here, and while it is very unpleasant to have to lock up plants where they cannot be seen except by visitors under escort, it has become necessary to do so in order to propagate and carry on experiments with plants which are often obtainable only at great expense of time and money.

Native Plants.—The valuable collection of native plants has been augmented by nearly two hundred packets of seeds collected in Modoc and Lassen Counties by Mr. Milo S. Baker; several packets from Mount St. Helena, Napa County, and Mount Shasta, collected by Mr. Willis L. Jepson; some especially desired rarities in the way of plants and seeds from Sonoma County, from Mr. F. T. Bioletti; thirteen packets of seeds from Humboldt County, collected by Mr. C. C. Marshall and presented by Mr. Chas. Weck; and several packets of seeds, and roots of plants collected by the writer around New Almaden, Santa Clara County, and Olema, Marin County.

Seed Exchange.—This important work has been considerably extended this year, no less than 1,950 packets having been sent out; almost all of these were distributed among the following institutions:

Department of Horticulture, Cornell University, N. Y.
Royal Gardens, Kew, England.
Royal Botanic Garden, Edinburgh, Scotland.
University Botanic Garden, Utrecht, Holland.
University Botanic Garden, Liège, Belgium.
University Botanic Garden, Parma, Italy.
University Botanic Garden, Tokio, Japan.
Botanic Garden, Florence, Italy.
Botanic Garden, Berlin, Prussia.
Botanic Garden, St. Petersburg, Russia.
Botanic Garden, Munich, Bavaria.
Botanic Garden, Glasgow, Scotland.
Botanic Garden, Upsala, Sweden.
Botanic Garden, Copenhagen, Denmark.
Botanic Garden, Durban, Natal.

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Botanic Garden, Melbourne, Victoria.
Botanic Garden, Brisbane, Queensland.
Botanic Garden, Cape Town, South Africa.
Botanic Garden, Wellington, New Zealand.
Argotti Botanic Garden, Malta.
Jardin d'Acclimatation, Geneva, Switzerland.
Royal Botanic Gardens, Seebpore, Calcutta, India.

Valuable collections of seeds have been received in return from the following places: Melbourne (the generosity of Sir Ferdinand von Mueller, the Government Botanist of Victoria, keeping us constantly supplied with freshly collected seed of valuable Australian plants), Cape Town, Helsingfors, Geneva, Kew, St. Petersburg, Durban, Florence, Utrecht, Edinburgh, Copenhagen, Tokio, Parma, and Malta.

DISTRIBUTION OF SEEDS, PLANTS, CUTTINGS, ETC.

By Edward J. Wickson.

The distribution of materials for trial by voluntary experimenters, which has been conducted by this Station ever since its establishment, has during the last three years attained an extent considerably greater than before. In the Report for 1890 summaries of this distribution are given for the five years preceding. Below are tables covering transactions since the Report for 1890, with totals of earlier distribution. University Bulletins Nos. 95, 98, and 103 give in detail the offerings of the years 1891 to 1893, inclusive. It is not desirable to reproduce these *in extenso*, as there is necessarily some repetition in the annual announcements. It will be better to present accounts of the plants in connection with notes from the reports received from our correspondents, and these will be found on following pages.

Concerning the plan of distribution, there is still some lack of apprehension on the part of the public, and to reduce this we reproduce the following statement:

Distribution is undertaken for the purpose of securing a popular verdict on the value and adaptability in all parts of the State of the growths which we have under observation on the grounds of the Central Station at Berkeley, and of the four outlying stations in Amador, San Luis Obispo, Tulare, and Los Angeles Counties. With this purpose in view, our distribution contemplates the acceptance of an obligation by the applicant to faithfully experiment with the material supplied, and to report success or failure. That this obligation is conscientiously discharged by a large proportion of our correspondents is shown by the full data credited to such sources in our recent reports. This distribution from the Station is for the purpose of securing wide trial of growths new to the State, and does not include common trees, plants, and seeds which can be had from dealers. For this reason, we do not invite applications for general supplies of garden seeds or fruit trees. We cannot furnish them. We cannot undertake distribution to citizens of other States, except where desirable exchanges are offered.

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Number of Plants and Cuttings Distributed.

Name.	Total. 1886–91.	1891–92.	1892–93.	1893–94.	Total.
Trees—Black wattle	185		114	38	337
Guava	303				303
Kikar	205				205
Olive	1,028				1,028
Camphor	985				985
Cork oak	803				803
Date palm	244				244
Melon	92				92
Strawberry	212				212
Sumac	46				46
Tea	108				108
English oak	470			38	508
Kai apple	408				408
Carob	136				136
Ironwood eucalyptus*			108		108
Lemon-scented gum			177	42	219
Balm of Gilead fir*				19	19
Western arbor vitæ				19	19
Austrian pine				21	21
Drooping cypress				23	23
White pine				20	20
Lawson cypress				17	17
Kentucky coffee tree				44	44
Eastern black walnut				48	48
Carolina poplar				28	28
Hackberry				34	34
Black ash				7	7
Pawlonia				40	40
Catalpa				38	38
California maple				58	58
Fiber plants—Esparto grass	210	50			260
New Zealand flax	470	30			500
Ramie	650	120			770
Forage plants—Australian salt bush	490				490
Texas blue-grass roots	8,370	504		456	9,330
Flat pea roots			1,610	1,610	3,220
Plants—Bamboo	666				666
Caper	501				501
Licorice roots	285				285
Taro		159			159
Jerusalem artichokes		1,680			1,680
Sugar cane		57		90	147
Logan berry				76	76
Henna plant				104	104
Cuttings—Grape	10,486	84	462	1,995	13,027
Mulberry	7,415	1,968	900		10,283
Willow	2,150	312	360		2,822
Olive	560				560
Figs			1,272		1,272
Totals	37,478	4,964	5,003	4,865	52,310
Scions—Fruit (number of orders)	232	32	38		302

*Substituted for Hickory wattle and Douglas spruce named in Bulletin.

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Weight, in ounces, of Seeds Distributed.

Name.	Total 1886–91.	1891–92.	1892–93.	1893–94.	Total.
Cereals—Wheats	4,912	736		2,432	8,080
Barleys	3,584	992			4,576
Oats	1,536	1,104			2,640
Ryes	768				768
Buckwheat	56				56
Rice				5	5
Fiber—Flax	1,552	80			1,632
Cotton	720	104			824
Jute	88	36			124
Forage—Grasses—Millet (*Milium multiflorum*)	307	72			379
Schrader's brome	1,655	128			1,783
Hungarian brome	1,024	128			1,152
Japanese wheat	634	176			810
Tall oat	231	88		268	587
Japan clover	86				86
Snail clover	678	92			770
Kaffir corn	962				962
Yellow millo maize	140				140
Black medic	210				210
Esparcette, or sainfoin	2,080	152			2,232
Tagasaste	327			78	405
Hairy-flowered paspalum	210	64			274
Jersey kale	346	156			502
Elliott's sida		115	116		231
Crimson clover			540		540
Wonderful cow pea				115	115
Garden—Corn	2,747				2,747
Peas	572	412			984
Pumpkins and squashes	421				421
Beans	814	312	126	231	1,483
New Zealand spinach	81	67	57	81	286
Beets	404	79			483
Carrots		61		134	195
Trees—Black wattle	555	53			608
Sumac	22				22
English oak acorns	624	500		385	1,509
Sundry—Pyrethrums	809				809
Quinoa	117				117
Chuna	39				39
Tobacco	471				471
Dyer's madder	19				19
Chapman's honey plant	192				192
Anti-gopher plant		73			73
Cañaigre			40	76	116
Totals	29,993	5,780	879	3,805	40,457

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Name of Grain and Variety.	Date when Sown.	Date when Harvested.	Rate of Product per Acre.
Barley.			
Erfurt	Jan. 28	June 19	73 bushels.
Peacock	Jan. 28	June 19	73 bushels.
Annate	Jan. 28	June 16	60 bushels.
Imperial	Jan. 28	June 15	59 bushels.
Six-rowed Black	Jan. 28	June 20	58 bushels.
Himalay	Jan. 28	June 14	57 bushels.
Thuringian	Jan. 28	June 16	53 bushels.
Two-rowed	Jan. 28	June 14	53 bushels.
Six-rowed Brenner	Jan. 28	June 18	53 bushels.
Black two-rowed	Jan. 28	June 12	49 bushels.
Himalayan	Jan. 28	June 17	49 bushels.
Frick's Drought-Proof	Jan. 28	June 18	48 bushels.
Black Spring	Jan. 28	June 9	46 bushels.
White Australian	Jan. 28	June 17	44 bushels.
Chevalier	Jan. 28	June 16	44 bushels.
Palestine	Jan. 28	June 12	40 bushels.
Italian	Jan. 28	June 10	40 bushels.
Large Naked Two-rowed	Jan. 28	June 10	39 bushels.
Bluish	Jan. 28	June 15	37 bushels.
Sprat or rice	Jan. 28	June 18	37 bushels.
Four-rowed Spring	Jan. 28	June 18	37 bushels.
Berkeley Hybrid	Jan. 28	June 15	33 bushels.
Manchurian	Jan. 28	June 1	32 bushels.
Kalina	Jan. 28	June 1	30 bushels.
Nepaul	Jan. 28	June 10	27 bushels.
Oats.			
Heavy Winter	Jan. 25	July 29	43 bushels.
Polish	Jan. 25	July 30	41 bushels.
Surprise	Jan. 25	July 25	33 bushels.
Scotch Hopeton	Jan. 25	July 27	31 bushels.
Mox Rust-Proof	Jan. 25	July 27	26 bushels.
Thuringian	Jan. 25	July 25	23 bushels.
New Black Champion	Jan. 25	July 30	21 bushels.
Podolish	Jan. 25	July 27	15 bushels.
Canadian	Jan. 25	July 25	15 bushels.
Probsteier	Jan. 25	July 6	15 bushels.
White Bolognese	Jan. 25	July 27	12 bushels.
Harris Alabama	Jan. 25	July 25	11 bushels.
Brown Joanette	Jan. 25	July 29	6 bushels.
Large Naked	Jan. 25	July 6	6 bushels.
Gray Winter	Jan. 25	July 30	5 bushels.
Rye.			
Swedish Sand	Jan. 25	July 6	27 bushels.
Excelsior	Jan. 25	July 28	24 bushels.
Perennial	Jan. 25	July 25	23 bushels.
Hungarian	Jan. 25	July 28	23 bushels.
Spanish	Jan. 25	July 25	18 bushels.
St. John's Day	Jan. 25	July 25	7 bushels.
Saxon Perennial	Jan. 25	July 25	3 bushels.
Flax.			
Royal of Germany	March 20	June 10	931 pounds.
Russian	March 20	June 10	660 pounds.
White-flowering French	March 20	June 10	520 pounds.
Yellow-seeded	March 20	June 10	391 pounds.

MOX RUST-PROOF OATS: *J. C. Weybright, Kaweah, Tulare County.*—Mox Rust-Proof Oats grew to about thirty inches in height and headed nicely, on soil of granite formation. I think these oats would do well here if sown early on summer-fallow.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Mox Rust-Proof Oats grew well and yielded abundantly; fine plump grain.

C. Wine, Timberville, Ventura County.—The Mox Rust-Proof Oats was not sown until the 3d of March. It grew to a medium height and yielded well. It did not rust.

H. Brundage, El Montecito, Santa Barbara County.—The Mox Rust-Proof Oats rusted considerably, owing, I presume, to my proximity to the coast (about 2,000 feet elevation) and superabundance of fog the past season.

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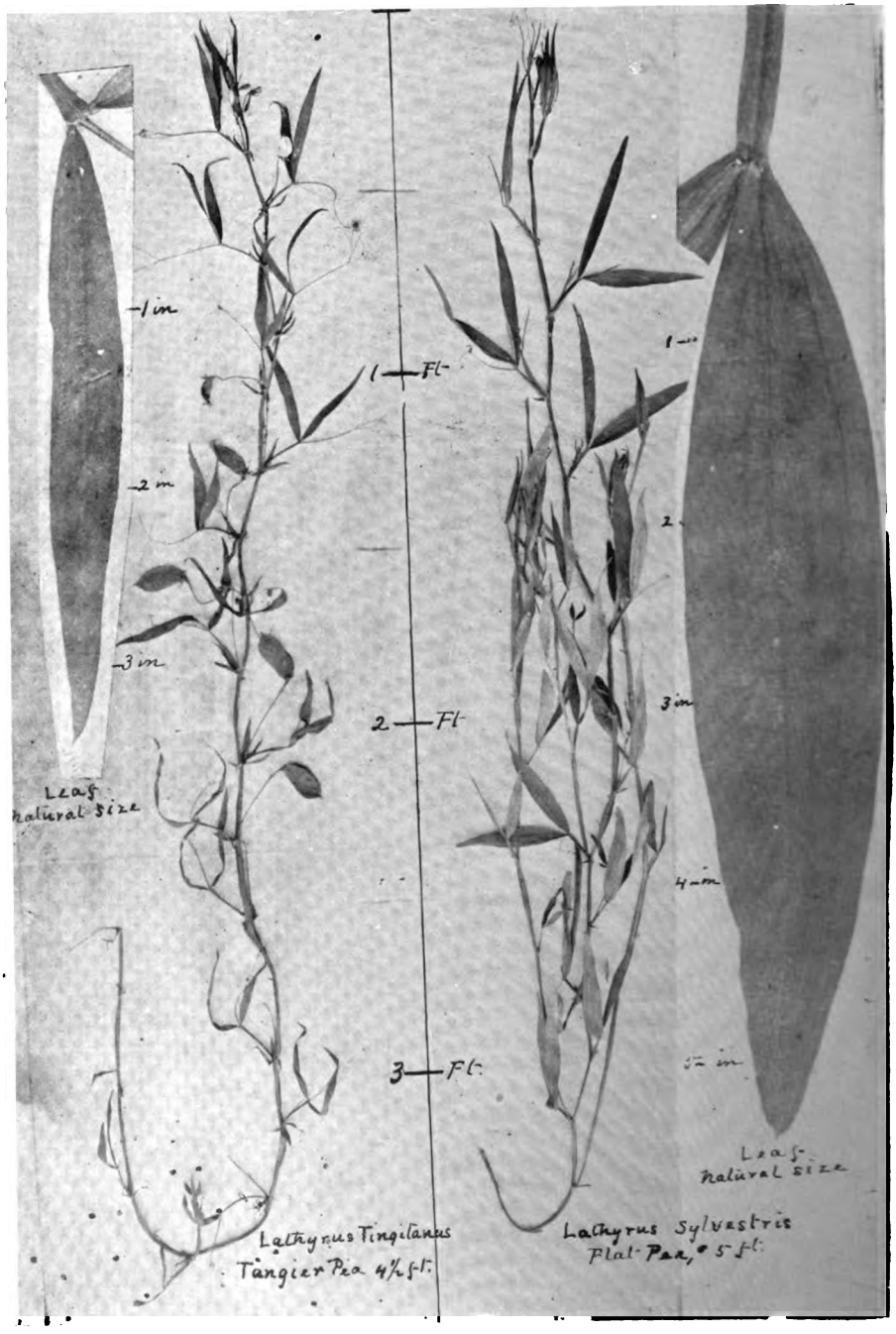

Two valuable FODDER PEAS distributed by the Central Station.

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HEAVY WINTER OATS: *Henry Montoux, Williams, Colusa County.*—Heavy Winter Oats are not as good as the Mox Rust-Proof, which are as productive as the Surprise Oats.

W. A. Morris, Fouts Springs, Colusa County.—The Heavy Winter Oats did not look as though they would amount to anything until the middle of June, but they grew 4 and 5 feet tall, and I got 63 pounds from one pound of seed. I suppose I lost one fourth by birds. They are free from rust.

George B. Pearce, Jr., Paradise, Butte County.—Heavy Winter Oats made a good crop for hay, but I saved them for seed. They yielded well. They did not get ripe until about the middle of July, and although the weather was very dry, they filled well.

BERKELEY HYBRID BARLEY: *Raymond Plasse, Jackson, Amador County.*—I sowed the Berkeley Hybrid Barley on the 10th of February and harvested it on the 20th of June. I sowed it in good ground in rows one foot apart; it grew to about 4 feet to 4 feet 10 inches high, with good heads. I harvested 45 pounds to sow this year from the one pound of seed.

M. S. Curtis, Dunlap, Fresno County.—I think the Berkeley Hybrid Barley is the best barley for hay I ever saw.

Henry Montoux, Williams, Colusa County.—Berkeley Hybrid Barley seems to be well adapted to adobe soil; its growth is quite satisfactory, especially for hay, as it is quite leafy and beardless.

Geo. B. Pearce, Jr., Paradise, Butte County.—Berkeley Hybrid Barley sown on common red soil grew rather short. I think it requires rather rich land to grow a paying crop.

ST. JOHN'S DAY AND PERENNIAL RYE: *H. D. Rowe, Willits, Mendocino County.*—The St. John's Day Rye I received March last has done nicely. Also the Perennial Rye. They yielded 25 pounds to one of sowing, which I call well for this climate and sowing so late.

GRASSES AND FORAGE PLANTS.

THE FLAT PEA: *Lathyrus sylvestris.*—This plant was widely advertised abroad and in this country in the year 1891. It had been under trial for a number of years previously on the Continent and in Great Britain. The plant is a perennial legume, and is found growing wild in North European countries. The credit for noting its promise as a forage plant is given to Prof. W. Wagner, of Kirchheim, Teck, who collected seed of the wild species and improved the plant by cultivation for ten years. Similar work is credited to Dr. Stutzer, of Bonn. The seed from which the plants at this Station were grown was received in 1891 from the U. S. Department of Agriculture, and is believed to be the Wagner seed.

Plants grown from this seed and planted out late in 1891 rapidly extended themselves, and practically filled the soil of the plot with rambling rhizomes. The second season there was a dense mat of haulm or vine formed, which covered the ground and reached a length of about four feet. All through the dry summer months it maintained a bright green and grew continuously. The top growth was cut away in September and fed to animals, which ate it readily. The plant did not bloom, and the cutting was for the purpose of stimulating new shoots from the running roots, so that we might have plants for this year's distribution rather than wait another year for the seed. After the cutting, the new growth started rapidly. Our observation thus far indicates that the plant grows vigorously throughout the dry season, at least in the coast region. Its foreign reputation gives it a very permanent rooting and long service in the most arduous situations.

Analysis of the fodder made at this Station gives the plant very high nutritive value. This analysis, compared with those of other forage plants, may be found in another portion of this report. An engraving from a photograph of a specimen of this plant, also of another valuable fodder pea (*Lathyrus tingitanus*), grown at this Station, is given herewith. The following are extracts from correspondence:

H. E. Brown, St. Helena, Napa County.—Flat Pea roots all grew and are strong and green. I am very much pleased with it and believe it will be a valuable forage plant for us. It was planted on adobe and had no care whatever.

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Robert Adler, Windsor, Sonoma County.—Flat Pea roots were planted at different points on my ranch and in various soils—chiefly clayey, and hilly land where the moisture was only that received from rain. While it was a severe test the result shows thrift. The roots have developed leaves and seem to be flourishing. I did not lose one plant, and the fact that we have had about 40 inches rain this season combined with white and black frost at different times shows this plant to be very hardy. If it can survive the drought of summer it will prove valuable.

G. S. Gilbert, Walker Valley, Mendocino County.—Flat Pea came up well and grew well. Animals broke fence and ate it close down and it has apparently died (but may come up).

L. Seiler, Shasta, Shasta County.—Flat Pea does first rate where the soil is reasonably moist and fertile. It has blossomed and borne seed abundantly.

I. A. Butchers, Pozo, San Luis Obispo County.—Flat Pea roots were planted on a rich sandy loam, damp enough for corn or potatoes. Some which was not irrigated grew but little, the runners 4 to 6 inches long; the irrigated plants grew better, but the weather seemed too hot. Chickens will eat it clean.

Wm. E. Whitmore, Whitmore, Shasta County.—I see nothing in the Flat Pea yet worthy of special commendation—being on new ground. I may say it did as well, perhaps, as alfalfa would have done with the same care.

F. S. Gould, Santa Barbara, Santa Barbara County.—Flat Pea in one situation grew very luxuriantly.

L. L. Guss, Brentwood, Contra Costa County.—Flat Pea on sandy soil made a fair growth and I think it will do well and will make good feed after it gets well rooted.

E. R. Pierson, Raymond, Madera County.—Flat Pea in our dry and hot location kept green all summer, but the heat was too great for it to do its best—the under leaves turned yellow and it stopped growing. The soil is granitic and a little irrigation was given.

Michael Gorman, San Ardo, Monterey County.—Flat Pea did fairly well, but hogs got at it in July and rooted it out and destroyed it all.

Dr. Edmund Goldmann, Wrights, Santa Clara County.—The Flat Pea plants made a fine growth, and I expect it will provide my pasture grounds with a new, valuable forage.

Mrs. J. L. Skinner, Wrights, Santa Clara County.—The Flat Pea roots all lived and grew all summer without watering; in the fall the hens keep it eaten down, but it continues to grow.

Geo. B. Pearce, Jr., Paradise, Butte County.—Flat Pea came up and grew nicely until about the middle of summer, when the tops died. I watered a few plants and kept them alive, but they grew only about a foot long without any cultivation.

W. C. Bradford, Arbuckle, Colusa County.—Flat Pea failed.

CRIMSON CLOVER: *Trifolium incarnatum.*—This strikingly handsome clover has been grown in our Garden of Economic Plants for many years. Although it made a very quick and luxuriant growth in winter, its disappearance early in the dry season condemned it as a dry land forage plant. If, however, the plant be estimated by its winter growth, it has valuable points, in localities suited to it, whether it be for early pasturage or more especially for producing a heavy crop while winter moisture is abundant, for plowing under as green manure in the early spring. During the last few years Crimson Clover has become very popular for such use in some of the Southern States, and there is abundant testimony of its value in refreshing orchard soils, for which it should be chiefly tested in this State. It is also worthy of note as a bee forage plant, and may serve the stock grower as well for winter feed, for it grows thriftily under temperatures which check the growth of alfalfa. The plant should not be confused with the common red clover of the East (*Trifolium pratense*), from which it is wholly distinct. It is clear, however, from the following reports, that the plant does not serve all California conditions:

John Jacob Schmidt, George, Clackamas County, Oregon.—Crimson Clover was sown in March; was in full bloom in June. I find it a worthy bee forage plant. A new crop grew from the seed which fell to the ground. During its bloom the bees liked it better than buckwheat close by. I got plenty of seed from it.

L. L. Guss, Brentwood, Contra Costa County.—Crimson Clover on sandy soil does not make a growth of over 4 inches in height. Sown with the first rains it does not bloom until April—too late to plow under for manure in orchards here. Alfalfa on same soil without irrigation makes two crops.

J. J. Veitinger, Jamul, San Diego County.—Crimson Clover came up well, but after dry weather it disappeared and by middle of May all was gone.

W. C. Bradford, Arbuckle, Colusa County.—Crimson Clover failed.

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Geo. B. Pearce, Jr., Paradise, Butte County.—Crimson Clover was sown about the middle of February. Just as it came up, we had quite a freeze, which killed most of it. A few plants escaped and made a nice growth. I think if sown in early winter before severe frosts it would be a good plant for plowing under for a fertilizer.

Mrs. John Shaw Wright, Willits, Mendocino County.—Scarlet Clover came up all right, but the winters in this section are so wet—so much freezing and thawing, that the plants were killed completely out. Alsike Clover, sown at the same time, went the same way.

TEXAS BLUE GRASS: *Poa arachnifera.*—This grass is quite fully characterized in our Report of 1890, and its growth favorably commented upon. The following are later reports, and cover a wider area of the State:

H. H. Gird, Fallbrook, San Diego County.—Texas Blue Grass furnishes some feed in early winter, but is overgrown by the native annuals in the spring.

Wm. N. Runyon, Courtland, Sacramento County.—Texas Blue Grass has done well on bottom land without irrigation.

John Jacob Smith, George, Clackamas County, Oregon.—Texas Blue Grass is very fine on my high hill-land. It is green all the winter and through the dry summer. It stood the hot sun well. Cattle are very fond of it. I have planted a large place with it.

Harry E. Watson, Guerneville, Sonoma County.—Texas Blue Grass did not make any growth worthy of mention outside of a specially prepared place.

E. A. Jenks, Garberville, Humboldt County.—Texas Blue Grass roots on good corn land, east slope, did not grow very well. I think the climate does not favor it.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Texas Blue Grass roots grew and are doing well.

Geo. B. Pearce, Jr., Paradise, Butte County.—Texas Blue Grass did not do much last summer, although it had water occasionally. A few stalks ran up about a foot high and then bloomed. It has spread some and is growing nicely now. I think it would make a good pasture grass after it got started.

Miss M. D. Eshleman, Fresno, Fresno County.—The Texas Blue Grass grew well on sandy land (our disintegrated granite sand)—surface irrigation.

Edmund Goldmann, M.D., Wrights, Santa Clara County.—Texas Blue Grass has not proved hardy enough to withstand the drought, which is the more surprising to me since I have been for a number of years a resident of that State and therefore know the ardent sun and withering droughts of that part of the country.

C. C. Reynolds, Kelseyville, Lake County.—The Texas Blue Grass was planted in red soil (our soil is all red) and given about the same cultivation that alfalfa had by the side of it. The alfalfa died—the blue grass is now 3 feet high and looking well.

L. L. Guss, Brentwood, Contra Costa County.—Texas Blue Grass dried out; not deep rooted enough for this soil. Another clover, called Spike Clover, is better suited for the sand; it makes a strong growth of about 3 feet and stands up well; is good feed while young.

S. I. Darling, Fruitvale, Alameda County.—The Texas Blue Grass is on light gravelly soil of a southern slope of the hills above Fruitvale, and has not been irrigated. It remained unscorched through the summer, and each single root has increased to the size of the whole package received, in spite of being cropped once by a cow that spied out its tempting greenness. Texas Blue Grass is a success.

Geo. A. Raymond, Miramonte, Kern County.—I notice that the Texas Blue Grass grows more or less right through these long dry spells where an alfalfa field is brown.

G. Lotman, Merced, Merced County.—The Texas Blue Grass did very well upon a hilly place, and has grown almost without any water. I have now one hundred times as many roots as I received.

Theo. G. Ed. Wolleb, Fruitvale, Alameda County.—The Texas Blue Grass roots were planted on poor, dry soil, and have not grown much; they are alive—that's all. Australian Rye Grass alongside did well.

H. Brundage, El Montecito, Santa Barbara County.—The Texas Blue Grass was only watered in the early part of the season, or until the certainty of the growth was assured, when I simply watched it during the dry season, which it weathered in good shape, stooling out plentifully. I think it will prove a desirable grass in this section. My ground is a sandy loam with gravel and bowlders underlying.

Sol. Beckom, Cahto, Mendocino County.—The Texas Blue Grass you sent me in March has done well, considering that the place where I planted it was shaded about half the day. When I set the roots out there were 13 in all, and in November I counted 64. I gave the plants one good irrigation in August; at that time they showed no sign of drought. It was on rocky clay land.

Robert Hastie, Clayton, Contra Costa County.—Texas Blue Grass is a failure.

ELLIOTT'S SIDA: *Sida Elliotti.*—This malvaceous herb is indigenous in the Southern States, and was sent to us for trial by Hon. G. D. Tillman, of South Carolina, whose experience with the plant is given on page 175 of our Report for 1892. Observation of its growth in Berkeley, which is also described in that report, led us to approve it for wider

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trial in waste places for a browsing plant, not for cultivated lands. It evidently does not succeed very widely, and yet under proper conditions may prove of considerable value. This is shown by the following notes from correspondence:

H. H. Gird, Fallbrook, San Diego County.—Elliott's Sida, on hillside granitic soil, came up in the spring (after the weather became warm) thickly. Rabbits, rats, and squirrels fed upon it continuously. It is green at this writing (December); average height, 8 inches; very bushy and full of seeds. It surely is hardy and must be good feed.

L. L. Guss, Brentwood, Contra Costa County.—Elliott's Sida, planted on sandy soil, made a good growth of a woody texture—too hard and tough for good pasture except for sheep and goats.

E. R. Pierson, Raymond, Madera County.—I planted Elliott's Sida in my garden and obtained a few plants which made a fair growth and matured a quantity of seed. Our extreme heat here in summer (110° or 112° in the shade) did not appear to affect the plant unfavorably, as it does almost everything. It was slightly irrigated; remained green throughout the summer and showed no signs of wilting.

Robert Hastie, Clayton, Contra Costa County.—Elliott's Sida was a complete failure. I transplanted some of 1892 plants on corn land. They grew well at first, but made no crop, and died in August.

L. Seiler, Shasta, Shasta County.—Elliott's Sida did not germinate, although planted at different times.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Elliott's Sida grew only about half a foot in height, and is still green (in January), having produced a quantity of seed. So far it has not been affected by the frost.

Solomon Agerter, Santa Cruz, Santa Cruz County.—Elliott's Sida I planted on upland; came up finely, but the birds took it up by the roots.

Henry Murphy, Milo, Tulare County.—Elliott's Sida seed was sown in March and April: but few seed came up. They made slow growth, being about 6 inches high. They were affected by the frost in December.

ESPARCETTE OR SAINFOIN: *Onobrychis sativa.*—This clover was urged quite loudly upon the public in the agricultural journals about four years ago. It was claimed that it would thrive on soils too dry for alfalfa. Our experience with the plant at this Station, for a decade or more, did not approve this claim, but we met the popular demand by offering the seed for general trial. Our Report for 1890 shows that the plant was, on the whole, a disappointment. The following notes from later correspondence tend in the same direction. They will be useful for future reference:

C. C. Reynolds, Kelseyville, Lake County.—Esparcette does well.

Geo. B. Pearce, Jr., Paradise, Butte County.—Esparcette or Sainfoin makes a better first crop than alfalfa, though the after-growth is not so good; however, I think it will stand more dry weather.

Edward C. Coburn, Middletown, Lake County.—Only a few plants or seeds of Sainfoin grew, but they seem to withstand drought well.

Robert Hastie, Clayton, Contra Costa County.—Esparcette or Sainfoin is doing fairly.

Mrs. J. D. McDonald, Burnt Ranch, Trinity County.—The Sainfoin did not do very well. I planted it on a very dry hillside where no stock could bother it; some was just scattered on the ground and the remainder sown on cultivated land, but it did poorly in both places.

Geo. B. Pearce, Jr., Paradise, Butte County.—Esparcette or Sainfoin made a good stand. Some that had the overflow from irrigating the orchard grew about a foot high and then went to seed; seemed rather inclined to spread out on the ground; some of it that did not get any water lived through, but did not grow much. It was sown on sidehill facing northwest; rather poor soil.

Geo. A. Raymond, Miramonte, Kern County.—I have tried for two seasons to get Esparcette started, but it seems almost impossible to succeed. What few have started seem to do well, but in spite of the assertion that it does best on a moderately dry soil, mine does best where near plenty of water—even on the inside of ditch-banks at the water-line and where the water is continually running. In fact, such are the only places where it has started.

L. L. Guss, Brentwood, Contra Costa County.—The Esparcette received two years ago is not suited for this soil (drift sand). It smothers and does not make a strong growth.

TALL OAT GRASS: *Arrhenatherum avenaceum.*—This grass must be considered one of the most promising of those so far proposed for arid conditions. This fact is shown by the account given of it in our Report

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for 1890. Since then we have continued the distribution of the seed, and later reports are as a rule confirmatory of the usefulness of the plant. We give the following:

Mrs. Theresa C. Keys, Alhambra, Los Angeles County.—Tall Oat Grass seed was sown in March and has been irrigated a number of times. It is growing and looking well but is far from tall. Our season has been so dry and cool that none of the plants or flowers have made the growth as usual. Flowers have gone to blossoming when only half their usual height, and presume this is the cause of the lack of height in the Oat Grass.

Robert Hastie, Clayton, Contra Costa County.—Tall Oat Grass did finely. From the old roots it yielded at the rate of three tons to the acre. It had no cultivation nor irrigation.

Edward C. Coburn, Middletown, Lake County.—Tall Oat Grass is valuable when once started.

H. H. Gird, Fallbrook, San Diego County.—The Oat Grass does well on damp land.

Mrs. Thos. Anderson, Olinda, Shasta County.—Tall Oat Grass proves to be, I think, a very valuable grass for pastures, as it is green all through the summer and has had no water; I think it will prove valuable for dry land. It grows like bunch grass with a turf and is always green and sweet. Stock are very fond of it. The seeds drop from the head, while the base of the plant is still green. It starts early and stays green all through the summer and fall.

OTHER FORAGE PLANTS.—The following brief extracts from correspondence relate to plants which have been fully discussed in earlier reports, and information concerning them can be supplied on application:

HUNGARIAN BROME GRASS: *Bromus inermis.*—*G. S. Gilbert, Walker Valley, Mendocino County.*—Brome Grass does remarkably well. Stood the drought of the summer well and is now thick and bunchy. Animals like it.

L. Seiler, Shasta, Shasta County.—Hungarian Brome Grass does well on reasonably fertile soil. I have some four years old, which comes from the root new every year. It keeps green longer than any other grass and sprouts again as soon as it gets a little moisture. I do not irrigate it.

E. A. Brinkerhoff, Forest Ranch, Butte County.—The Hungarian Brome Grass survived the severe drought of the past summer, but only grew 2 or 3 inches high and has remained green. In good soil I think it would do well.

JAPANESE WHEAT GRASS: *Agropyrum Japonicum.*—*H. H. Gird, Fallbrook, San Diego County.*—The Japanese Wheat Grass is a very lusty grower; good feed, and extends itself freely, but not quite equal to *Milium multiflorum* on dry ground.

Robert Palmer, Havilah, Kern County.—I am very much pleased with the Japanese Wheat Grass. I sowed it in February, and after I gathered the ripe seed in July; it made a rapid growth in large tufts. It is now quite green (January), in spite of many heavy frosts, and is over a foot high. It promises to be an excellent winter feed in the mountains.

JOHNSON GRASS: *Sorghum Halapense.*—*Eugene Melvin, Paradise, Butte County.*—I have a plot where the lava rock is barely covered with from a few inches to a foot and a half of dry, rocky soil, which I planted with Johnson Grass roots. It makes very good summer pasture; it is neceesary, however, to plow the land late every spring, as it bakes after the heavy rains. I am well pleased with it for that kind of soil, and shall continue planting all that kind of soil I have to it, but I do not like to plant it on good soil on account of its tendency to spread.

Wm. H. Mullen, Big Bend, Butte County.—I never have had anything that would grow well on dry land but Johnson Grass, and that I wish I never had tried. Stock do not like it for hay, but will eat it when young and green.

SNAIL CLOVER: *Medicago turbinata.*—*Robert Hastie, Clayton, Contra Costa County.*—Snail Clover did well till it dried up; then the rabbits took all of it, and they made it go as far as possible, for they commenced at the outer points and ate it down gradually to the roots.

Jos. Geschwend, Sur, Monterey County.—The Snail Clover in a dry sandy soil made a growth of from 2 to 4 feet and matted all over the ground. The hay was at once fed to cows, and they liked it very much.

E. R. Pierson, Raymond, Fresno County.—I sowed the Snail Clover in a light sandy soil on a dry hillside, where it grew from 8 to 12 inches high. It starts earlier and remains green longer than any of the native clovers growing in a similar location.

TAGASASTE: *Cytisus proliferus albus.*—*H. H. Gird, Fallbrook, San Diego County.*—Tagasaste failed to come up the first year, but the next fall came up thickly early in the season, and all died in January—probably from too much moisture.

Mrs. E. M. Edwards, Olinda, Shasta County.—Tagasaste planted in August is growing finely, and is about 2 feet now (January 26th).

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N. S. Adams, Raymond, Madera County.—Tagasaste seed is very hard to start; some will stand in water for days without any visible change, but I find if the least particle of shell is removed they will swell as quickly as wheat, and will germinate readily without previous soaking.

TEOSINTE: *Reana luxurians.—W. M. Bristol, Messina, San Bernardino County.*—On April 28th I planted a small plot of Teosinte on dry upland soil of good quality. It received no irrigation until October 1st; was benefited some, however, by a heavy shower in August. When thoroughly watered it made a vigorous growth, some reaching a height of 10 feet. As a forage plant I believe it will prove of great value for the hot interior valleys where water for irrigation is abundant. It has the appearance and taste of corn fodder, but is sweeter.

JERUSALEM ARTICHOKES: *Helianthus tuberosus.—Mrs. Emily Brown, Kelseyville, Lake County.*—Brazilian Artichokes planted two years ago on gravelly soil and irrigated have multiplied well. The ground is alive with them wherever I dig in the vicinity of the first planting. One year ago I took up a start and planted in a more favorable spot of ground, twelve hills, and they made large hills of artichokes. I did not measure but I think there were fully one half bushel in bulk in the twelve hills. I think they exceed the yield of anything else on the same ground. I pare them and cook as salsify and they also make nice soup. I cook them for my chickens. They also make pickles.

Chas. Gloeckner, Healdsburg, Sonoma County.—The Artichokes turned out well. Out of about one dozen plants I got about a sackful. They make fine feed.

David Richardson, Santa Paula, Ventura County.—The Artichokes came up and grew, but lacking enough moisture failed to mature.

M. Gorman, San Ardo, Monterey County.—White Artichokes grew very well, but the Red Brazilian seem better than the white.

Henry Montoux, Williams, Colusa County.—Jerusalem Artichokes planted about the 15th of March yielded from six to eight large tubers to the hill. My milch cows and pigs seem to relish them.

E. A. Brinkerhoff, Forest Ranch, Butte County.—Jerusalem Artichokes have done the best of anything I have tried in a poor dry soil. The package I got from you yielded 40 pounds. The white produced twice as much as the red. Neither had any water and were on a sidehill in a clay loam.

Solomon Agerter, Santa Cruz, Santa Cruz County.—The Red Artichokes did not do as well as the white, in moist ground, but the white yielded beyond expectation, producing 20 pounds and over to the single eye, and the cattle eat them with a relish.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—The Jerusalem Artichoke (White French and Red Brazilian), of which I received five bulbs of each, all grew splendidly, and to the height of 6 feet. The White French produced a large burlap sack of bulbs. The Brazilian would have done equally as well, only the gophers got at them, consuming over half before discovered.

E. A. Jenks, Garberville, Humboldt County.—I have planted Jerusalem Artichokes and raised large crops, but hogs will not eat them raw. I have to cook them and put wheat with them or my hogs will not eat them.

JERSEY KALE.—*J. Hardin, Pope Valley, Napa County.*—Jersey Kale, on rather dry ground, did not do very well.

Robert Hastie, Clayton, Contra Costa County.—Jersey Kale did very poorly. Land too dry.

Solomon Agerter, Santa Cruz, Santa Cruz County.—Jersey Kale yields bountifully. The cattle eat it with a relish; also in its early stages it makes excellent greens for table use. I have some now growing that have attained a height of 5 feet.

W. A. Morris, Fouts Springs, Colusa County.—Jersey Kale grew 4 and 5 feet tall, with very broad leaves. Good for cattle.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Jersey Kale grew tall and strong, producing a great amount of feed. It was often cut down, but always came up strong and thrifty.

Jos. Geschwend, Sur, Monterey County.—Jersey Kale is a famous plant, growing here under any fair treatment 6 feet; and such an amount of fodder that a man would not want to pack more than three stalks. I think 6 feet apart for the plants would be better than 4, as I have them.

TREES AND SHRUBS.

Supplementary to reports in earlier publications of the Station, the following notes are selected from our correspondence:

ENGLISH OAK: *Quercus robur.—C. Brower, Bakersfield, Kern County.*—The English Oaks manifested a surprising vitality, though this may have been partially on account of their longer roots and stouter stems—and in spite of the glowing heat upon the surrounding sand, as well as their denudation of foliage by rabbits which had found their way within the inclosure, they survived the summer and made fair growth. This was a surprise to me, as I planted them with grave doubts of their ability to withstand the heat and dryness of our atmosphere, but I now regard them as well adapted to our climate.

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BLACK WATTLE: *Acacia decurrens.—Mrs. Almeda Frakes, Del Sur, Los Angeles County.*—Black Wattle trees came up and grew finely. I have over a hundred trees from the package of seed, some about 15 inches high.

Abner L. Butterfield, Escondido, San Diego County.—I have one Black Wattle tree, which I raised from seed I received from the Station five years ago, that is 11 inches in diameter at the ground and between 30 and 40 feet high.

E. R. Pierson, Raymond, Fresno County.—The Black Wattle seems best suited to this locality as far as can be judged from a single season. It stands excessive heat and dryness, and quite severe frosts.

CAROB: *Ceratonia siliqua.—Abner L. Butterfield, Escondido, San Diego County.*—I have one Carob tree that I raised from seed that a missionary brought from the East. It bore a few pods with full-grown seed this summer. It is in blossom now (December), and has been for a month. There are quite a lot of little pods on it now. Some of the blossoms appear to be perfect, and some staminate only. There is no other tree of the kind anywhere near here. There are none within several miles.

KAI APPLES: *Aberia Kaffra.—Jos. Burtscher, Auburn, Placer County.*—Kai Apples are doing very well.

J. C. Harvey, Los Angeles, Los Angeles County.—Kai Apples are flourishing with me, and doubtless will bear fruit in this section.

J. Wallace F. Diss, Redlands, San Bernardino County.—One of the Kai Apple plants was given the best of care; the other scarcely any, only receiving water twice during the year. The latter did every bit as well as the one well cared for, and both have put forth a strong, vigorous growth, showing themselves well adapted to this climate.

E. R. Pierson, Raymond, Fresno County.—The Kai Apples stand our very hot weather better than the cold. Mine were injured by frost, though they were covered with sacks. They need to be well strawed, or given some secure protection against freezing weather.

CAPERS: *Capparis spinosa.—J. Wallace F. Diss, Redlands, San Bernardino County.*—The Capers have not done well, and it is my impression that they would do better in a damper atmosphere.

W. R. H. Weldon, Ventura, Ventura County.—The Caper plants grow nicely, giving an abundant supply of blossoms from May 15th until frost comes, when they are killed down to the ground. I do not think that they would be a commercial success here.

COFFEE: *Coffea arabica.—Jacob Miller, Colegrove, Los Angeles County.*—I have a Coffee tree in full bearing, ten years old.

VEGETABLES.

NEW ZEALAND SPINACH: *Tetragonia expansa.*—Described by Von Mueller as a good culinary herb and as useful for restraining drifting sands; growing even during severest heat and drought. Our correspondents speak of it also in the highest terms as a table vegetable.

T. Phillips, Simi, Ventura County.—New Zealand Spinach does finely and seems to be at home.

Mrs. L. Weitz, Farmington, San Joaquin County.—New Zealand Spinach was sown on the 16th of March, and on the 20th the big flood came over it, but did not hurt it. It grew all summer, until late in November the frost killed it. Some of it was 7 or 8 feet long. It was well watered and in very rich ground.

S. C. Dondore, Lakeside, San Diego County.—The New Zealand Spinach I received last year is growing nicely, without irrigation, and I consider it an excellent article for table use.

Geo. Jordan, Colfax, Placer County.—New Zealand Spinach proved a great success in every respect.

J. Hardin, Pope Valley, Napa County.—New Zealand Spinach got a very late start, but kept growing till frost.

Robert Hastie, Clayton, Contra Costa County.—New Zealand Spinach is the "boss" vegetable. It grows all summer on very dry land. It is a beautiful dark-green to-day (November 18th). It is worth a place in the flower garden where water is scarce, and for the table it has no superior—to my taste. It stands very little frost, but the growth came up from the old roots and did well after being frozen down. The top growth seems as easily killed by frost as the tomato. I have had it in good cutting order in January, but not quite so much of it is fit for use as in spring, on account of it being rather stringy.

S. F. Thorn, Glenwood, Santa Cruz County.—The New Zealand Spinach has made a wonderful growth, running over 5 to 6 feet, though we are constantly cutting and eating it. Boiled with bacon, pork, or a piece of ham, it is the most agreeable vegetable for greens that we have thus far found.

MELDE'S PERENNIAL BEAN.—A handsome, large, white bean, with a perennial root, from which climbing runners start each year. The seed was donated by Mr. Henry Melde, of Humboldt County.

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J. Harper, Sonoma, Sonoma County.—Melde's Beans grew very well and flowered all summer.

Mrs. L. Weitz, Farmington, San Joaquin County.—Melde's Beans would have done very well, but the bugs kept the blossoms all eaten off until after July; after that time I got about 5 pounds of green beans from four vines.

Mrs. Geo. F. Reid, Nita, Lake County.—We planted the bean in a rich, black soil. The chickens got at it and ate all the flowers and leaves off; then I fenced it in and it bloomed again and think that I would have had more beans but the humming-birds broke the flowers off before they should have fallen. I will plant the beans that I have saved, for I think they are very nice.

CEYLON PEA.—This variety of table peas was received by us from Ceylon; its true varietal name not being known to us. It has proved a very productive and desirable late pea.

Dr. Edmund Goldmann, Wrights, Santa Clara County.—Ceylon Peas came up splendidly and yielded such an excellent crop last summer that they now have superseded all other kinds in my vegetable garden. We are having some of them to-day (December 31st) on our dinner table, and it is not unlikely we shall have them all winter.

Robert Hastie, Clayton, Contra Costa County.—Ceylon Peas sown January 22d made a first-rate crop of excellent quality.

A. B. Burdick, Kaweah, Tulare County.—Ceylon Peas prove to be a good grower. The yield was heavy and large; full pods of a fine quality of peas. With me it is as good as the best.

Abner L. Butterfield, Escondido, San Diego County.—The Ceylon Pea is very nice and yielded the best of any kind I have ever tried here.

H. H. Ward, Escondido, San Diego County.—Ceylon Peas did not grow nor yield as well as other varieties that were alongside of it.

Minnie Neligan, Creston, San Luis Obispo County.—The Ceylon Pea grew splendidly. I never saw such large pods as it bore.

ECLIPSE AND OSBORN BEETS.—Early red table beets:

Geo. A. Raymond, Miramonte, Kern County.—The Eclipse and Osborn Beets started easily and made good growth with irrigation. Beets were of fair size and remarkably tender and sweet.

MISCELLANEOUS.

TOBACCO: *Ragland's Conqueror.—B. F. Roberts, Mossy Glen Ranch, Leighton, Shasta County.*—The plants which I grew from Ragland's Conqueror tobacco seed were set during the first week in May on ground from which a crop of lettuce had been taken. The soil is loose and sandy, and had received no fertilizer save a moderate coat of stable manure, not thoroughly decomposed, early in the spring. The plants were shaded for a day or two, and about two weeks subsequently received one irrigation and a day or two later a hoeing. No further attention was given save topping and sprouting. The first crop was ripe by July 15th, but was not cut until a month later. The ten leaves to a stalk averaged 30 inches long by 12 inches wide, and have made a most excellent quality of smoking tobacco without any doctoring. After cutting, one shoot from each stalk was allowed to grow, and a second crop matured and was cut November 15th—of very fair quality. The stumps are still alive and will produce other crops next year. My tobacco has been tested and examined by several persons—some of them experienced tobacco-raisers from the East—and all unite in pronouncing mine of a superior quality.

Yellow Oronoko.—L. Wilkinson, Middletown, Lake County.—The Yellow Oronoko tobacco seed I gave a fair trial, and I find it the best I have seen raised on the Pacific Coast. I have full confidence that I can make tobacco a success in California.

GOPHER PLANT: *Euphorbia lathyris.—Edmund Goldmann, Wrights, Santa Clara County.*—I had the Gopher Plant seed sown close by some carrots which gophers were destroying, yet the animal captured the carrots just the same. My opinion of the plant, to keep gophers away, can scarcely be a very exalted one.

Robert Hastie, Clayton, Contra Costa County.—The Gopher Plant is a humbug. I have grown it along my garden fence for twenty years and the gopher runs under and round it all the time.

E. A. Jenks, Garberville, Humboldt County.—I have the Gopher Plant growing in my orchard, but gophers live there also.

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LIST OF DONATIONS

Made to the Experiment Stations Since December, 1892, with Brief Notes on Some Results.

In the following acknowledgment of gifts of seeds and plants that the Agricultural Department of the University has received since our last report, lack of space prevents us from making a complete and itemized catalogue. We desire, however, to express our thanks to all our correspondents in this department of the Station work, and assure them that their continued interest will be cordially appreciated.

The system adopted by the Stations respecting donations of seeds, scions, cuttings, bulbs, plants, and trees is extremely simple. We are always glad to receive samples of new or rare varieties or species, and give them all possible care at the Central Station, or at the sub-stations, as seems best under the circumstances. We register everything as soon as received, and do not distribute nor propagate (except for experimental purposes) without the permission of the person sending us the stock. We do not sell stock under any circumstances. The interest of the Station workers in new plants is wholly scientific, and not commercial.

Persons sending seedling fruits for testing, however, should remember that we desire only varieties of real promise, and always with notes, as far as possible, upon the origin and history of the seedling. We cannot test large and miscellaneous lots of wholly untried seedlings. The originators must bring them into bearing, and compare the results with standard varieties to the best of their ability.

We always have large orchard trees to work over, besides small nursery stock, and can receive scions or buds of new varieties in the season, and top-work immediately. Correspondence from fruit-growers, nurserymen, and amateur hybridizers is always welcome.

Exchanges on the part of the Station include everything in our collection, subject only to the limitations imposed by the originators, or the proprietors, of varieties not yet introduced, and to the general principle that the Station must not incur any financial loss in such exchanges. As with seeds, special distributions of scions will be made, at times. The Station particularly desires the coöperation of progressive horticulturists in the work of securing as large a representation as possible of Pacific Coast seedling fruits of every class and species.

PLANTS AND TREES.

From Superintendent John McLaren, of Golden Gate Park, San Francisco, Cal.:—Five hundred and seventy trees for planting on the top of Mount Hamilton, around the Lick Observatory. This fine collection included six species of Acacias, two of Cypress, and seventeen of Pine; also Ericas, Ulexes, and Genistas for ornamental work. Among the pines were P. massoniana, P. sylvestris, P. nigra Austriaca, P. Laricio, P. mitis, P. Torreyana, P. sabiniana, P. insignis, P. maritima, P. pinea, P. Coulteri, P. monticola, and P. halepensis.

From Mr. Brakefield, of Hall Valley, on the Mount Hamilton road, east of San José, Santa Clara County, California:—Scions of a seedling apple of promise.

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From S. L. Watkins, Grizzly Flats, California:—Plants of fifteen varieties of strawberries, including the following: Hood River, Great Pacific, Stonebreaker, Sierra Red Alpine, Graham, Montreuil, Saunders, Wolverton, Lady, Carolina Superba, Early Dawn, Western Prolific, Far West, Gillespie, and Dollar. This collection was sent to the Southern California sub-station, in the Chino Valley, where the foreman is paying particular attention to small fruits.

From J. Coppin, Loomis, Placer County, California:—Trees of a seedling almond, with samples of the nuts. A large hard-shell of very fine appearance for the type.

From Alexander & Hammon, Biggs, Butte County, California:—Trees of the following sorts: Blue Pearmain and Winter Banana apples; California Red plum; Sneed, Japan Blood, Brooks' Butte, and Buck's Prolific peaches; Spark's Mammoth apricot; Olmstead nectarine. Several of these, such as Brooks' Butte peach, are new and unusually promising California seedlings not yet widely known, but deserving the attention of horticulturists.

From Frank Owen, Monticello, California:—Scions of a new seedling apricot raised by him, and popular in his district.

From E. B. Silva, Newcastle, Placer County, California:—Plants of Tippecanoe and Dollar strawberries. The Station is indebted to Mr. Silva for stock of new fruit on several occasions.

From Father Agapius Honcharenko, Ukraina, Alameda County, California:—Cuttings of an olive from Mount Lebanon, also of a grape from the same region. Both are from the famous monastery gardens. The grape has been propagated for the sub-stations under the name of Honcharenko.

From J. C. Shinn, Niles, California:—Trees and plants of the following species for the sub-stations: Quercus suber, Dracæna indivisa, Sabal palmetto, Chamærops excelsa, Phœnix dactylifera, Mahonia Aquifolium, Syringa vulgaris; also 300 bulbs of Amaryllis, Narcissi, and Gladioli for the sub-station gardens; also trees of English and of Persian walnuts, and of Hatch Seedling No. 2 almond.

From W. J. McLean, Julian, California:—Scions of six varieties of apples and one of peach, chiefly new California seedlings of more than ordinary merit.

From R. C. Kells, Yuba City, California:—Scions of Bishop grape, a noted California seedling.

From W. King, Arroyo Grande, California:—Five trees of a seedling apricot.

From C. F. Loop & Sons, Pomona, California:—Seventeen varieties of olives.

From J. S. Calkins, Pomona, California:—Fourteen varieties of olives.

From Alfred Wright, Pomona, California:—Eight varieties of olives, one Yucca, and one Erythræa edulis.

From Leonard Coates, Napa, California:—Trees of Weedsport prune, a new variety here.

From Mr. Meserve, Pomona, California:—Ten ornamental plants and one Phœnix canariensis.

From Mrs. A. Skinner, Pomona, California:—Cuttings of twenty-two named varieties of roses; also water hyacinths for aquatic garden.

From John Gamble, Haywards, California:—Roots of a jointed grass (*Poa stolonifera*), brought by him from Ireland.

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From J. V. Cotta, Carroll County, Illinois:—Scions of ten varieties of apples, all new to this coast, and several not yet in commerce.

From Joseph Hart, Fayetteville, Arkansas:—Vines of a new seedling grape.

From Prof. W. H. Massey, North Carolina Experiment Station, Raleigh:—Cuttings of several new figs, sent to the Tulare sub-station.

From Prof. E. R. Lake, Experiment Station, Pullman, Washington:—Scions of six new apples and one new plum. Several of these are as yet unknown in California.

From Harrison, Storrs & Co., Painesville, Ohio:—One tree of Harris apricot, and several greenhouse plants.

From S. R. Kramer, Kingston, Ohio:—One vine of Uller's Mammoth grape, originating in Ohio, about 1885.

From T. V. Sluman, Mount Tabor, Oregon:—Trees of Pacific prune, a large blue prune highly praised in the Northwest, where it originated.

From George Ruedy, Colfax, Washington:—Trees and scions of Palouse apple, Moore's Arctic plum, Stewart Ironclad peach, a new seedling pear (not named), and a new seedling prune. The Palouse apple has been much praised as a market fruit, but is not yet known in California.

From Seth Lewelling, Milwaukee, Oregon:—Trees of Bing cherry, an Oregon seedling introduced by him, and of great local reputation.

From P. J. Berckmans, Augusta, Georgia:—A very fine collection of Southern fruits, embracing eighteen varieties of apples, two of apricots, two of figs, twelve of peaches, two of nectarines, one of mulberry, seven of pears, and five of plums. All of these are new to California growers, as far as known, and the list includes some very promising fruits for the warmer parts of the State. As with other new fruits now at the Station, the full description must wait till a complete catalogue can be prepared.

From J. H. Hale, South Clastonbury, Connecticut:—Trees of Crosby peach.

From O. M. Goodrich, Fellowship, Florida:—Fifty seedling American persimmons from selected seed. These have been distributed to sub-stations, and partly used for stock.

From W. F. Heikes, Huntsville, Alabama:—Trees of five new varieties of Southern peaches; also of one new plum, one new pear, one new cherry, and three new apricots. Like the collection from Mr. Berckmans, this is a typical and interesting collection from a very reliable source.

From C. E. Pennock, Fort Collins, Colorado:—Ten plants of the Improved Dwarf Rocky Mountain cherry. These were distributed to the sub-stations, and planted at the Central Station. They bloomed the first week of April, 1894. Mr. Pennock also sent cuttings of a New Rocky Mountain willow.

From Walling & Jarisch, Oswego, Oregon:—Stock of a number of new and standard varieties of fruit, including the following: Red Romanite and Virginia Greening apples, Russian apricot, Champion prune, Bing cherry, Early Charlotte peach, White Grape and Black Naples currants, Souhegan raspberry, and Oregon Everbearing strawberry. Trees and plants were received at two different times from this firm.

From McGill & McDonald, Salem, Oregon:—Trees of Tennant prune, an Oregon seedling of promise.

From H. A. Corliss, St. Helena, Oregon:—Plants of two varieties of seedling gooseberries, of high local reputation.

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From E. P. Smith, Gresham, Oregon:—Trees of Oregon peach (in dormant bud); scions of Blaine apple. Both are new seedlings of the Northwest, of local reputation.

From E. M. Beuchly, of Greenville, Ohio:—Scions of Downing's Winter Maiden Blush apple. Mr. Beuchly had previously sent plants of his noted El Dorado blackberry and Greenville strawberry.

From J. T. Lovett, Little Silver, New Jersey:—Scions of Lincoln Coreless pear, of Lincoln plum, and of Fuller quince.

From Prof. Charles S. Sargent, Arnold Arboretum, Cambridge, Massachusetts:—Trees of Asiatic oaks for the Forestry Stations. A fine collection, representing five species, and several varieties, all rare and very important for our growing arboretums at Chico and Santa Monica.

From Prof. L. H. Bailey, Cornell University, Ithaca, New York:—Scions of twenty-one varieties of American plums.

From A. W. Thornton, Whatcom County, Washington:—Cuttings of new gooseberries.

From Superintendent Thomas Sharpe, Government Experiment Station, Agassiz, British Columbia:—Scions of forty-seven varieties of apples and pears, mostly new to this region. Some of these varieties are very old English and French sorts; others represent very recent introductions from England, and one or two are Canada seedlings. A very interesting collection.

SEEDS.

From Gustav Briere, Los Angeles, California:—Seeds of Cytisus laburnum, for the Forestry Station.

From Sunset Company, San Francisco, California:—Seeds of thirty-seven named varieties of sweet peas.

From Mrs. J. D. McDonald, Burnt Ranch, Trinity County, California:—Seeds of a native grass. Mrs. McDonald writes that it "grows on heavy clay soil, keeping green the year round. When the soil is so dry that it is almost impossible to drive a pick into it, and is cracked open, the grass will be green and thrifty." Cattle and horses are said to be very fond of it. The normal height of the grass is about ten inches.

From F. P. Hosp, Redlands, California:—Seeds of a plant called "Poselle," from Siam, said to be a valuable fruit-bearing annual.

From W. A. Lawson, Los Angeles, California:—Seeds of South African Mimosas, Proteas, and other species, in all nine, seven of which are probably new to this region.

From D. M. Dimmick, Santa Barbara, California:—Seeds of the new cow-pea "Wonderful."

From H. C. Cone, Thermal, Fresno County, California:—Seeds of a native grass said to grow on the driest soil, remain green, and furnish excellent pasturage. Height of grass, 26 to 39 inches.

From Hon. Horace Davis, San Francisco, California:—Package of a new wheat produced in the Mokelumne River region.

From W. J. Strachan, Foreman Forestry Station, Santa Monica, California:—A collection of seeds from Hawaiian Islands; also coffee beans, gathered by Mr. Marcuse in Mexico; also seeds collected in Santa Monica.

From W. H. Maule, seedsman, Philadelphia, Pennsylvania:—Seeds of the "Wonderful Sugar Melon," and of Begonia Vernon.

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From W. Atlee Burbee, seedsman, Philadelphia, Pennsylvania:—Thirty-five packets of vegetable and flower seeds for trial in the grounds. Some of these are new and not yet sent out to the general trade. Distributed to the sub-stations.

From Northup, Braslan, Goodwin & Co., seedsmen, Minneapolis, Minnesota:—Twenty-one packets of vegetable and flower seeds for trial. Distributed in smaller packages to sub-stations.

From the Iowa Seed Co., Des Moines, Iowa:—One package of Gold Mine corn.

From Peter Henderson & Co., seedsmen, New York:—Five packages of new varieties of seed, sent out for trial.

From Professor Thomas Meehan of Philadelphia, Pennsylvania:—Seeds of Lawsonia alba, the famous Henna plant of the Orient.

From Chauncey M. St. John:—Seeds of the White Ebony tree.

From A. B. Jones, Hartford, South Dakota:—New hybrid barley "Success."

From Delano Moore, Presque Isle, Maine:—Seeds of Pomroy bean, Carsley cucumber, and Alexander tomato.

From the Louisiana Experiment Station, Baton Rouge, Louisiana:—Twenty-three varieties of sweet potatoes—a fine named collection, elsewhere reported upon more in detail.

From the Agricultural Department, Washington, D. C.:—Two mail-bags full of packages of seeds for distribution to the Central and sub-stations. This extensive collection included varieties of corn, melons, lettuce, turnips, radishes, beans, egg-plant, peas, celery, tomatoes, and other garden vegetables, besides tobacco, grasses, and forage plants. Hon. Stephen M. White also sent some twenty packages of Department seeds, which were redistributed, together with a part of the seeds sent direct from the Department, to individuals who have agreed to report results.

The Assistant Secretary of the Department also sent four packages of Sunn Hemp seed (*Crotalaria juncea*); this was subdivided, and sent to the sub-stations, and to a few individuals, with directions for culture.

The Department also forwarded seeds of Cata-Caos cotton, from Peru. This cotton is further described in the report on the Southern California Station. Also from the Department, selected chestnuts from Mount Etna.

The Pomological Division sent seeds of Persea gratissima (the "avocado" of Mexico). The seeds were gathered from trees that stood a temperature of 22° at the blooming season, and are believed to be the hardiest strain of this noted fruit.

From Don Luciano Santa Maria, U. S. Vice-Consul, Medallin, United States of Colombia:—Seeds of the "Comino Crespo" tree.

From Nathaniel Meirs Cox, of Santiago, Chile:—Seeds of twenty-seven species of Chilean trees, shrubs, and vines, with valuable descriptive notes. An important and interesting collection mostly gathered upon Mr. Cox's estate, Mansel.

From Dr. L. Trabut, Director of the Jardin d'Acclimatation du Hamma, Algiers:—Forty-two varieties of cereals, chiefly wheats and barleys. This collection includes some very large and fine milling wheats, and the size of the kernels of both wheat and barley is extraordinary. From the same botanic gardens came seeds of Fraxinus dimorpha, which were sent to the Forestry Stations.

From the Botanic Gardens of Florence, Italy:—A collection of seeds, including some rare South American palms.

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From the Royal Gardens at Kew, England:—Thirty-eight packets of rare seeds, which include three species of Berberis, five of Cytisus, two of Eleagnus, four of Acer, four of Pyrus, seven of Alnus, four of Cratægus, two of Cornus, and others of interest and value.

From Robert Veitch, seedsman, Exeter, England:—Ten packages of new varieties of flowers and vegetables, distributed to the Central Station and sub-stations.

From Baron Ferd. Von Mueller, Government Botanist, Victoria, South Australia:—Seeds of Gordon Pasha cotton, Pesco melon, several varieties of Atriplex, and some thirty packets of valuable seeds from Australia. Also, collection of eighty-two species and varieties of grasses, clovers, economic and forage plants, and garden vegetables, chiefly from South Asia.

From the Royal Botanic Gardens, Calcutta, India:—Three packages of rare tree seeds, with others to follow.

From the Botanic Garden at Saharanpur, Northern India:—A very fine collection of seeds of thirty-three species of Indian trees, and fourteen kinds of vegetables. There is certain to be something of value to California in both the above-mentioned collections.

From W. Farrer, New South Wales:—Through the courtesy of J. E. Watson, of San Francisco, a collection of new Australian wheats, also seventeen hybrid wheats, his own crosses; sent for further tests and developments under California conditions.

From A. B. Robin, South Australia:—Seeds of Para Grove tomato, a new variety of good local reputation.

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SYNOPSIS OF METEOROLOGICAL OBSERVATION

(Students' Obs

North latitude, 37° 52′ 21.7″. Long

For the year ending June 30—	1888.		18
BAROMETER.			
Mean barometer for the year		30.017	
Highest barometer for the year	Jan. 17, 7 A. M.	30.501	Feb. 1, 7 A.
Lowest barometer for the year	Jan. 4, 2 P. M.	29.516	Mar. 16, 7 A.
Yearly range		0.985	
Highest monthly average	December	30.131	February
Lowest monthly average	August	29.908	September
THERMOMETER.			
Mean temperature of the year (Fahr.)		54.9	
Mean temperature of the warmest month	June	62.1	July
Mean temperature of the coldest month	January	45.0	January
Maximum temperature	October 10	89.5	July 15
Minimum temperature	January 14	24.9	February 17
Yearly range		64.6	
Greatest monthly variation	October	41.4	May
Least monthly variation	July	23.7	December
Mean daily range of temperature		14.3	
Mean lowest temperature of the year		48.8	
Mean highest temperature of the year		63.1	
PRECIPITATION.			
Rainfall during the year		19.235	
Dew and fog during the year			
RELATIVE HUMIDITY.			
Mean relative humidity of the year		82.8	
Greatest monthly variation	October	63.5	October
Least monthly variation	August	29.4	December
Maximum humidity	July 14, 7 A. M.	100.0	Mar. 12, 9 A.
Minimum humidity	Oct. 10, 2 P. M.	31.9	Oct. 21, 2 P.
Yearly range		68.1	
WEATHER.			
Number of clear days		183	
Number of fair days		89	
Number of cloudy days		94	
Number of foggy days		48	
Number of days on which rain fell		58	
WIND OBSERVATIONS.			
Description of prevailing wind	Southerly		Southerly

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Footbill Station Building, Jackson, Amador County

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B. THE FOOTHILL STATION.

Five miles north-northeast from Jackson, Amador County.

By CHARLES H. SHINN.

The work of the Experiment Station during 1893 has been along the track outlined in the previous reports. A new vineyard has been planted on a slope of the smallest of the three hills of the Station farm. The orchards, both on the granite and on the red soils, have received additions. Considerable clearing has also been done, and in such a manner as to leave fine specimens of our native trees scattered over the tract. Brush, stones, and logs thrown across several gulches have retained much of the "wash" from higher slopes, and thus the formation of level "flats" for cultivation has been greatly assisted. More stone wall has been built, and some of the worst portions of the road drained permanently by stone channels at the sides. A new hay barn and tool shed has been added to the permanent improvements of the Station, the old stable and shed affording insufficient accommodation.

The General View.—A general view of the Station work for the year is upon the whole encouraging, though it is a large piece of ground to handle with no more labor than we are able to spend thereon. It is necessary for us to care for long stretches of mountain road, and this is both difficult and expensive. Labor and supplies of every sort are more expensive than in the valleys. The birds and wild animals trouble the vineyard, orchard, and garden. Visitors seldom find their way to the Station, and few of those who do come are farmers or interested in any department of horticulture. There is no community of farmers and fruit-growers close to, and surrounding the tract, as there is at the other outlying stations. In all essential particulars, the Sierra Foothill Station is an outpost thrust out into a sparse population of miners, teamsters, lumbermen, stock-raisers, and scattered agriculturists. Constant warfare against difficult conditions is the price of its existence; it is like one of the old border marches of the days of chivalry, a frontier settlement to be kept by the strong hand.

The long, narrow, hour-glass shaped county of Amador has horticultural possibilities quite as great as those of Placer, but Placer has the railroad extending through almost its entire length, while much of Amador is inaccessible except by a stage or private conveyance. As a result, Amador is in precisely the same condition as much of the fine hill country of the lower Sierra—the mining period is passing, but the fruit-growing and gardening period is not yet above the horizon. Men are not planting orchards; land holdings are becoming larger instead of smaller; in many cases magnificent water supplies, capable of irrigating vast areas, are running to waste. This condition of affairs, however, cannot endure. Means of communication will improve; tourists and campers will crowd the upper portion of the county, and little by little

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the famous old group of mining towns scattered along the "mother lode" in the heart of Amador, will grow into closer relationships and stir with new life. Like Butte and Placer, Amador will, sooner or later, attract settlers of the horticultural type.

At present and for some years to come, the work of the Station is less local and more for a large district. One of its orchards is upon soil of the coarse, thin, granitic type, so common in the Sierra, and so universally condemned as "too poor to grow pasture." Another orchard is upon the red soil that has produced such excellent fruits in other Sierra districts. Trees and grapevines are being duplicated on these two most typical soils, and it has already been shown that the granite soils are well adapted to many cultures, and respond rapidly to the proper fertilizers. One of the best four-year-old cherry trees on the whole Station tract, photographed for the Midwinter Fair, was a "California Advance," on granite soil, grown without fertilizers or irrigation, and most of the orchard trees have done fairly on this soil.

The general aspect of this picturesque mountain station is both pleasing and impressive, from all its approaches, lying as it does across and among a group of three hills and over a long rocky ridge well covered with pines, oaks, manzanitas, and other native growths. The Station will amply repay a visit from any mountain farmer or fruit-grower. Stage lines reach Jackson from Valley Springs, Ione, and Volcano. May and June are probably the most pleasant months in which to visit the Station, but fruit-growers would find more to see in September.

THE ORCHARD.

The effort to plant similar orchards on granite and red soils has made greater expense than was expected, and will continue to do so for some time to come, but as it is obviously impossible to tell beforehand what varieties will thrive better or worse on either soil, it becomes necessary to duplicate all kinds, and watch results. Small, compact orchards, well arranged and thoroughly studied, are better from every point of view than large, mixed orchards. We have therefore confined the representation of varieties, with few exceptions, to one tree of each variety on each soil, and have made the divisions of sub-orchards as distinct as practicable.

Quite a number of seedlings are in the orchard; some of these were planted by the late Inspector as tests and for future stock; others have grown from the stocks of dormant buds that failed. These seedlings, and some varieties that are mentioned under sub-heads, are now ready to be top-worked with new fruits as fast as desirable, and form a new orchard asset.

Indeed, if I were planting an experiment orchard on soil of a uniform grade, I should try to proportion the various sub-orchards as nearly as I could to the probable demands of the future, and should set in orchard form enough seedlings to enable new introductions to be top-worked, thus saving the loss of time incurred by propagation in nurseries. In many cases we should find after a few years that we only needed a branch or two of some varieties, and one tree could thus carry several sorts. We shall discard much in time, but for purposes of study and comparison the more extensive our lists are in some directions, the better it will be.

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THE SUB-ORCHARDS.—At the Foothill Station we now have on the granite soil sub-orchards of cherry, plum and prune, apricot, pear, apple, and almond. To these we shall add nectarines, figs, Japan persimmons, and other fruits. The territory at our command for this orchard being so nearly filled, we shall lay out a new granite soil orchard whenever it becomes necessary. When the few remaining gaps are filled, the present orchard will contain 279 trees. It occupies the lower portion of the northeastern slope of Reservoir Hill, and extends from the granite soil vineyard to a line of mulberries along the road by the mining ditch. On the east are eight olives, in the olive avenue. If the Station could obtain a few acres more of land on the north, both the orchards on the granite and the red soil could be extended with greater ease.

On the red soil there are sub-orchards of pear, apple, plum and prune, nectarine, apricot, peach, almonds, and cherries, while olive, chestnut, fig, persimmon, walnut, and other fruits are represented. The main orchard on this soil occupies the northwestern corner of the tract, extending from the main entrance and olive avenue to the north line. A small addition to the orchard extends south across the avenue, on a slope of Residence Hill. The almonds are on a southern slope of Reservoir Hill, parallel to the olive avenue, and the cherries are below and east of this avenue, in a very sheltered nook. When all the gaps are filled, these sub-orchards on the red soil will contain 557 trees, and some extension southward is practicable.

There is, however, no more room in the apple sub-orchard, and a new one must soon be established. The pear orchard, on the contrary, contains room for many more of the new and promising varieties now obtainable through our correspondents.

The varieties represented at this Station, as at the others, will be found tabulated in the supplement, together with home-station orchards.

Apples.—The list represented here is not sufficiently extensive for so wide and varied a mountain district. Apples do fairly well, and in some cases particularly so, and we can place here our new Southern apples, many Western varieties, and some new ones from England and France. Mr. Hansen reports of the apple orchard generally: "Growth healthy and promising. Three trees showed blossoms." It will probably be necessary to extend the red-soil apple orchard down the slope toawrd the main entrance, on a light soil unsuited for further pear trials.

Almonds.—The climatic difficulties of the district reveal themselves distinctly in the culture of the almond. Although the fig grows and fruits well, the almond is still a doubtful crop, though some varieties promise fair success. The growth of all the varieties represented at the Station was excellent. Sultana and Paper-shell both blossomed very heavily in the spring of 1893, but the flowers were destroyed by a fall of snow in March. Sultana bloomed a little afterwards, but with poor results. Drake's Seedling and Languedoc blossomed later, just after the snowfall, and developed excellent nuts. I X L also yielded a little. Under the circumstances, it is remarkable that any almonds at all were obtained.

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The following table will exhibit some details respecting some of the above-named varieties, all that fruited to any extent:

Variety.	First Leaf.	Full Leaf.	First Flower.	Full Flower.	When Ripe.	No. of Nuts.
I X L	Mar. 27	April 7	Mar. 3	Mar. 9	Aug. 27	89
Languedoc	April 6	April 19	Mar. 7	Mar. 27	Sept. 7	367
Drake's Seedling	April 1	April 14	Mar. 8	Mar. 20	Sept. 5	173
Sultana	Mar. 22	April 4	Mar. 6	Mar. 8	Aug. 18	51

This table is instructive and can well be compared with the almond table in the report on Paso Robles Station. The late-blooming varieties are all that it will do to plant in such districts. The old Languedoc, a poor bearer in valley districts, where hundreds of acres are in almonds, is, so far, more reliable than the Sultana or I X L. The reason is plainly to be seen in the blooming period. Languedoc flowers began to show March 7th, two days before the snow, and through the first few days blossoms were probably lost. The tree, however, continued in bloom till March 24th. Five sixths of the crop had therefore a chance to develop. Drake's Seedling might do better another year, and the Bidwell's Mammoth Hard-shell would probably be safe. The present season will be a very important one in the history of the almonds at the Station. At Colfax, in Placer County, as reported by Mr. Chas. Evans, "soft-shell" almonds have not fruited for several seasons, the late frosts killing the flowers. Commercial almond-growing is considered a failure there.

Apricots.—The Station has the beginnings of a most excellent collection; several sorts represented here (among them Boulbon and Esperen) are not yet in any of our other orchards. Many of the trees are making a strong growth, and are extremely healthy. The apricot often does fairly on both the granite and the red soils, but one strange difficulty occurs—sometimes a tree "dies piece-meal," branch by branch, when nothing out of the way can be discovered with root or stem. Mr. Hansen reports a loss of six trees on the granite and of three on the red soil, most of them among the oldest and best trees. Those on the red soil received some sub-irrigation through the berry rows, but the granite-soil orchard received no water. The old settlers say that many apricot trees die in this manner, even when very large trees, both on the level bottom lands and on the ridges.

Like most of the Station fruits, the apricot is a favorite of birds, squirrels, and other marauders. The following table exhibits the only two varieties that bore fruit.

Variety.	First Leaf.	Full Leaf.	First Flower.	Full Flower.	When Ripe.	No. of Fruits.	Fruit to a pound.
Beauge	April 5	April 15	March 22	March 29	July 14	212	11
Hemskirk	April 7	April 15	March 27	March 5	July 15	64	7

This tabulation, though too scanty for many deductions, illustrates the shortness of the probable apricot season in this region. The long period of equable and comparatively cool weather so common in the best cherry and apricot regions of the Coast Range is entirely lacking here; one week brings out the flowers, and a second week the leaves,

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while in less than a week from the first ripe apricot, both varieties had yielded their whole crop. However excellent this feature may prove for those who wish to dry apricots on a large scale, it is not an advantage for the canner, or for the planter of family orchards.

Plums and Prunes.—The hill-country is eminently well adapted to standard and late-blooming plums and prunes, as well as to the peach, but there are many local difficulties to be overcome, as the founders of many of the most prosperous mountain colonies have discovered. A great deal of fruit set on many trees at the Station, but the birds "completely plundered the early kinds." Mr. Hansen writes, "Burbank and Kelsey in particular had nice crops, but I did not get one single fruit in a perfect state; most of them were eaten or knocked off before they were half grown." The fruit was remarkably sweet in those cases where any were allowed to ripen; nearly all the trees show a superb growth, and blossomed very freely in the spring of 1893. The plum and prune sub-orchard on the red land has been frequently visited by bands of deer that browsed on the leaves and fruits. They preferred the plums to apples or peaches and spoiled the shape of many trees. Their visits are made at night, and no ordinary fence is any bar to them. As the trees get larger, they will become too sturdy to suffer to any great extent, but here, as in many other districts, the horticulturist suffers heavy losses for the benefit of the sportsman and camper. The only plums and prunes of which any fruit could be saved are reported in the following table:

Variety.	First Leaf.	Full Leaf.	First Bloom.	Full Bloom.	When Ripe.	No. of Fruit.	Lbs. to Tree.
Prune d'Agen	April 18	April 27	April 7	April 11	Sept. 29	183	17
Columbia	April 27	May 5	April 20	April 25	Sept. 14	238	8
McLaughlin	April 20	April 23	April 19	April 27	Aug. 9–19	57	8
Prince Englebert	April 20	April 28	April 20	April 25	Sept. 14–18	96	16
Datte de Hongrie	April 26	May 1	April 26	April 30	Sept. 17–20	97	32
Victoria	April 20	May 1	April 18	April 21	Sept. 14	88	10

All these are five-year-old trees, grown without irrigation, on the hill-sides. The large yield of the sweet and firm Datte de Hongrie, nearly twice that of the ordinary French prune, is worthy of notice. McLaughlin is a fine old sort, of large size, small pit, and very good quality. Prince Englebert is described as "exceedingly rich in sugar." At Colfax, I am told, the late frosts usually destroy the early-blooming Japanese plum fruits.

Cherries.—Only half a dozen varieties have yet fruited. Olivet bore a large and promising crop, but the birds carried every one away. It will be necessary to protect the fruiting trees, another year, with mosquito netting, if any tests are to be made. The Station is so surrounded by wild lands, that poisoning or shooting even large numbers of birds must have little effect.

The dying "branch by branch" disease, noticed in the apricots, is well shown in the cherry trees. First "one branch wilted, then another," till the entire tree above the graft perished. No borers were present, nor was there any unusual gum-flow as is common in the valleys. The trees already lost when of good size are Black Eagle, Empress Eugenie, and Black Tartarian. The Reine Hortense tree will be the next one to die. The Report of 1888–89 mentioned the fact that

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a great deal of gum was flowing from the cherry trees, but it disappeared the following year, and comparatively little has been seen since. There is more, in fact, now, than for several years past. Mr. Hansen reports the case of a large tree at Sutter Creek dying from this disease. It would be useful to know the system of pruning followed in this Sutter Creek case.

Nectarines.—Two nectarines, Early Newington and Victoria, bore fruit, but some "person or persons unknown" carried off the small crop before it could be gathered.

Pears.—The pear orchard is undoubtedly the most difficult sub-orchard at the Station. It is in the western part of the tract, between olive avenue and the corner, extending up the slope from the main entrance. Six rows were planted here, and well planted, five years ago. The first row, along the fence, subject, of course, to the evil influences of trees, brush, and grass outside, is practically dead now; the second is almost dead; the third can be called alive; fourth, fifth, and six show successive improvement. Even the hardy and rapid-growing Japanese seedlings have done very poorly in the first three rows, and are not even fit for stocks. The soil of the long slope set to pears is too light and porous, very different, though red in color, from the rich, red clays of the true fruit soils; it contains much quartz-gravel, derived from ledges traversing the regular slate.

The Apple Orchard.—Apples, so far as observed, do much better on this soil than the pears, and as there is need of more space for apples, they will probably be extended to the olive avenue, leaving rows four, five, and six to constitute the pear orchard. It may prove that a third plantation of pears on the strongest soil of the Station will be necessary before a success can be made of the fruit. The growth of the pears on the granite soil is much better.

Peaches.—Observations upon peaches have been more complete than those upon any other sub-orchard. The main orchard is on red soil, southern and southwestern exposures, and somewhat sheltered from the winds. The lesser orchard, on granite soil, was planted later, and is not so well situated, while the soil is poorer; nevertheless, a fair growth for mountain land has been obtained even here.

The oldest peach trees were planted in the winter of 1888, and are now yielding fruit. The soil received no irrigation, nor fertilizers of any description. It was rough hillside land, to begin with—such land as exists over an immense territory in California. As a rule, the peach orchards heretofore planted in this part of Amador County, in pioneer days, were upon richer and more moist soils. Allowed to overbear, and seldom or never pruned, they soon ran wild, and became valueless. Many such old orchards were cut down for firewood. In the warm and fertile Ione Valley, more accessible to outside markets, many fine peach trees are found.

The spring of 1892 was a very early one at the Experiment Station, but that of 1893 was quite late for the district, as the following table shows:

Variety.	Bloomed.		Ripened.	
	1892.	1893.	1892.	1893.
Chinese Cling	Mar. 8	April 7	Aug. 17	Aug. 24
Nichol's Orange	Mar. 8	April 11	Sept. 4	Sept. 10
Jennie Worthen	Mar. 21	April 14	July 7	July 13

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These three represented the earliest, the mid-season, and the latest blossoming varieties, and, as noted, the season of bloom was from three to four weeks later in 1893 than in 1892, but in actual ripening the delay was only six or seven days. No appreciable difference in size of flavor was reported between the peaches of the two seasons, 1892 and 1893.

As at the other stations, peaches that ripen the earliest fruit show leaves and flowers later, not earlier than other varieties. Out of sixty-two varieties listed at Amador, nine of the twelve that were last to blossom (after April 1st) belong to the early half-cling type. This and other points are illustrated in the following table, which gives the statistical record of the peach orchard on red soil. All the trees were on peach roots; and all of the trees represented, except Ulatis, Grover Cleveland, Mary's Choice, General Bidwell, and Thisell's White, are five years old; those named are one year younger.

The peach tables from other stations have been arranged alphabetically, but in the original table, as prepared by Mr. George Hansen, foreman of the Amador Station, the peaches were arranged in order of ripening, and it has been thought best to retain this order, for one season, at least. Comparative notes on some varieties follow the table:

Statistics of Peach Orchards—1893.

Variety.	First Leaf.	First Flower.	Ripening Season.	No. of Fruits.	Weight in lbs.
Alexander	April 14	April 2	July 8–17	114	23
Briggs' May	April 12	April 1	July 8–13	15	6
Shumaker	April 12	April 1	July 10–16	167	30
Governor Garland	April 12	April 1	July 10–16	213	36
Jennie Worthen	April 14	April 3	July 11–18	66	11
Waterloo	April 17	April 1	July 13–16	51	9
Amsden	April 12	April 2	July 13–15	38	7
Ulatis	April 15	April 2	July 15–18	104	26
Early Rivers	April 4	March 26	July 20–29	384	64
Strawberry	April 11	March 31	July 21–26	89	15
Hale's Early	April 14	April 2	Aug. 3–7	109	17
Early Rose	April 1	March 29	Aug. 12–14	20	3½
Tuskena Cling	April 3	March 29	Aug. 12–24	209	42
Foster	April 9	March 29	Aug. 14–24	71	14
Coolidge's Favorite	April 8	March 27	Aug. 14	14	3
Early Crawford	April 4	March 29	Aug. 15–23	108	22
Chinese Cling	April 4	March 25	Aug. 19–27	62	21
Royal George	April 10	March 30	Aug. 22	24	4
Grosse Mignonne	April 8	March 29	Aug. 23–29	265	30
Mary's Choice	April 6	March 31	Aug. 23–29	60	9
Noblesse	April 13	April 3	Aug. 24–29	144	20
Honey Cling	April 5	March 27	Aug. 25–Sept. 1	82	14
Elberta	April 6	March 26	Aug. 25–Sept. 2	155	34
Large White Cling	April 5	March 30	Aug. 27–Sept. 3	93	18
Muir	April 12	April 1	Aug. 28–Sept. 7	167	30
Late Crawford	April 1	March 29	Aug. 29–31	45	10
Albright's Cling	April 2	March 29	Sept. 1–6	76	22
Susquehanna	April 6	March 29	Sept. 2–7	52	10
Newhall	April 2	March 29	Sept. 2–6	253	72
Oldmixon Free	April 4	March 30	Sept. 2	23	4
Grover Cleveland	April 7	March 30	Sept. 4	28	7
Wheatland	April 4	March 30	Sept. 4–6	96	24
Runyon's Orange	April 11	March 31	Sept. 4–9	123	35
Seller's	April 2	March 30	Sept. 5–7	101	30
Heath's Cling	April 7	March 30	Sept. 6	60	13
Mrs. Brett	April 7	March 28	Sept. 6–12	300	60
Lemon Cling	April 2	April 1	Sept. 6	63	16
Oldmixon Cling	April 3	March 28	Sept. 6	42	10
Morris White	April 7	March 30	Sept. 8	47	9
Nichol's Orange	April 9	March 30	Sept. 9–14	120	24
California	April 1	March 30	Sept. 9	74	12
McDevitt's Cling	April 8	March 29	Sept. 11	42	11

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Statistics of Peach Orchards—Continued.

Variety.	First Leaf.	First Flower.	Ripening Season.	No. of Fruits.	Weight in lbs.
Picquett's Late	April 9	March 30	Sept. 14	57	12
Lovell	April 5	March 30	Sept. 14–16	158	26
Stump the World	April 5	March 26	Sept. 14–17	196	39
Late Admirable	April 9	March 27	Sept. 14–16	148	29
Indian Blood	April 8	March 28	Sept. 14	104	16
Columbia	April 5	March 30	Sept. 14–16	56	19
Thissell's White	April 7	March 30	Sept. 27–Oct. 1	61	14
Garey's Hold-On	April 5	March 29	Sept. 28–Oct. 2	90	30
Crimson Beauty	April 7	March 29	Sept. 29–Oct. 2	167	56
Beer's Smock	April 10	March 27	Sept. 29–Oct. 1	203	40
Smock Late Free	April 9	March 30	Sept. 30	24	5
Salway	April 13	March 29	Oct. 1–8	73	16
Wilkins' Cling	April 8	March 31	Oct. 1	25	5
Bonanza	April 9	March 26	Oct. 2	69	17
Wager	April 7	March 29	Oct. 2–14	211	46
Henrietta	April 10	March 31	Oct. 2–14	267	67
Ward's Late Free	April 4	March 31	Oct. 2–7	35	6
George's Late Cling	April 1	March 29	Oct. 6	56	10
General Bidwell	April 10	March 28	Oct. 27–Nov. 2	42	8
Bilyeu's Late	April 5	March 25	Oct. 29–Nov. 4	31	5

The following notes upon the above varieties complete the story of the season:

Alexander, white-fleshed, semi-cling, yielded excellent fruit. The tree was thinned on June 20th, taking off ten fruits. Time of leafage (*i. e.*, of coming into full leaf,) 19 days; of flowering, 9 days.

Briggs' May (California origin), white flesh, semi-cling, was best of early varieties; pit small, no thinning.

Shumaker, yellow flesh, nearly free, is a highly colored variety; time of leafage, 21 days, of flowering, 13 days. Thinned twice, 53 peaches taken off. Good example of an important type—that of the extremely early yellow peaches.

Governor Garland, white, semi-cling, is well-colored, with a pleasant acid. Like Shumaker, it is a heavy bearer; thinned twice, and 121 peaches taken off.

Jennie Worthen, nearly free, yellow flesh, was heavily thinned, and 134 fruits taken off. It needs further testing.

Waterloo, white, and semi-cling, is a trifle bitter at the pit; it is a well-colored fruit; was thinned once, and 27 peaches taken off.

Amsden, another white semi-cling, has a somewhat acid fruit, and lacks in juice, here.

Ulatis, seedling of Alexander, and earlier in some localities; it has a white flesh, semi-cling like its parent, and is of California origin; somewhat acid.

Early Rivers, freestone, of pale straw-color, short leafage period, but has a blossom period of 14 days. The fruit is of fair size and quality; it was thinned very heavily—562 peaches being picked off, and 384 left to ripen. This weighed 64 pounds—one of the heaviest crops in the orchard.

Strawberry, white, freestone, red at pit, very highly flavored, and exquisitely colored. It was thinned well, 137 peaches being taken off.

Hale's Early, red flesh near skin, freestone, "too sweet to be pleasant." It was thinned heavily, 224 fruits being taken off. This may not be true to name, as it should ripen with or before Strawberry.

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The above eleven varieties seem to have ripened in a somewhat different order from that which obtains in the valleys. Professor Wickson's "California Fruits" gives the approximate order of some leading varieties of the early class, as follows: Briggs' May, Alexander, Amsden, Ulatis, Waterloo, Governor Garland, Early Rivers, Hale's Early, Strawberry. In practice, the "first early" varies in different seasons. It sometimes happens that Alexander, Briggs' May, and Amsden ripen nearly together. Ulatis, at the Amador Station, was one week behind Alexander, but in Solano County it ripens quite as early. A break of five days between the first ripening of Ulatis and of Early Rivers marks the passing of the "first earlies," and with the Strawberry the highly-colored, fragrant, "rare-ripe" types begin. Early Rose, a rather dry, small peach, bridges the gap to the clings and the market yellow peaches; the Red Rareripe and Amelia are better peaches for the season, but have not yet come into bearing at the Station.

Tuskena Cling (the Tuscan and Tustin of many catalogues), the earliest cling at the Station, and different from Tuscany, showed many doubles. Thinning took off 114 peaches, and left forty-two pounds. It ripened practically with Foster, Coolidge's Favorite, and Early Crawford. Of these three standard varieties, Foster bore fairly well; fruits large and good quality, needed little thinning. Coolidge's Favorite did very badly, even after 168 fruits had been taken off, leaving the tree seemingly able to carry the crop. The fruit did not appear to mature well, though highly colored. Something of the same sort occurred with this variety at Paso Robles. It should probably be discarded, as there are better kinds for the season. Early Crawford, after light thinning, matured excellent and highly colored fruits.

Chinese Cling, the type of a large number of varieties, chiefly originating in the Southern States, is a very large, oblong peach. At Amador Station it is well flavored, red near the pit, flesh white and juicy, but very downy.

Royal George—"Too sweet to be agreeable," but highly flavored, is the report from the Station. This is a similar peach to the Red Rareripe, or Large Red. Another old variety of European origin, Grosse Mignonne, required heavy thinning (164 fruits), and was still poor in quality. Two similar peaches pass under this name in the United States. The true old French variety has a large flower, and ripens with the Foster, or earlier. Mary's Choice, a large, yellow freestone, of the Crawford type, ripened with Royal George.

Noblesse, a fine old English variety not often grown in California, is reported by Mr. Hansen as "very high flavored." This variety was seventeen days coming into leaf, and was ten days in flower—rather long periods for its type. The pale-green skin, sometimes clouded with light red in the sun, gives this peach a singularly colorless appearance.

The Honey Cling represents a very attractive new type, popular in the South. There is no sweeter or more highly colored peach in the collection. In thinning, 184 fruits were taken off, as the tree was small, and the 82 left weighed 14 pounds.

Elberta and Susquehanna are both good, large yellow; Muir and the Late Crawford fill in well between them—the total range of the four sorts being about a fortnight. A coarse down grows on Elberta, and to a lesser degree on Susquehanna. All of these color up well in the

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mountains, and would make good shipping peaches. All required considerable thinning, from 45 to 167 fruits being taken from each tree.

Newhall, a most excellent yellow peach, of California origin, bore 253 fruits, weighing 72 pounds, the heaviest crop in the orchard. The fruit was firm, juicy, highly colored, and ripened in four days. This variety in the valleys usually ripens a week before Crawford's Late; in this case it ripened four days later.

Among the main crop clings, Albright, an El Dorado County seedling (yellow), had very large fruit, sweet and well flavored. The Large White Cling, an old New York variety, was of medium size, highly colored, excellent. Slightly earlier than Albright's.

Grover Cleveland, a yellow cling originating at Vacaville, also Runyon's Cling and Seller's Cling, both California yellow peach seedlings, and all three standards for canning and market, were notable among the peaches of the first week in September. Immediately after Seller's comes the classic Heath Cling, the fruit of which was cracked by showers that did not affect the California seedlings or the fine Lemon Cling of South Carolina, or Oldmixon Cling, both of which ripened at the same time with Heath Cling—September 6th.

The notable freestones of the first week in September were the yellow Wheatland, of New York, juicy, high-colored, and very beautiful, and Mrs. Brett, a very famous variety, thriving in many districts. Though nearly 300 fruits were picked off, as many were left to ripen, and 66 pounds was the crop. Medium size, flesh white, red at pit, sweet and rich.

Morris White, which ripens the second week in September, is "almost without color," but very sweet, juicy, and spicy. This is an old favorite for canning and home use. Almost identical in time of ripening are Nichol's Cling and California Cling, both of them rather coarse, large, Orange Cling type, made familiar in Runyon's and Seller's, and both of California origin. Nichol's was much the better peach. The other was not first-rate in any particular. Two days later, the McDevitt's Cling, a Placer County seedling, began to ripen large, solid, but uneven fruit.

Six peaches began to ripen September 14th—Picquett's Late, Lovell, Stump the World, Late Admirable, Indian Blood Cling, and Columbia. All but one of these are freestones; the first two named are yellow. Lovell ripens here a week later, proportionately, than in the valleys, where it usually comes in with Grover Cleveland Cling. Stump the World, a very poor peach at Paso Robles, and rather losing ground everywhere, has no particular excellence here, but ripens very late for the variety; it belongs to the Oldmixon Free season, which peach it much resembles. It is fully a fortnight ahead of Picquett's Late. The Indian Blood Cling, which seldom is of any value on the lowlands, becomes "very sweet and highly flavored."

There is a notable break of eleven days between the last ripening of Columbia and the first of Thissell's Free, the latter an unusually white peach, delicious flavor, one of the best. Though this peach seems true to variety, its extreme lateness is worthy of notice. Professor Wickson lists it between Crawford's Late and Seller's Cling, which would make the Amador season over three weeks after time.

As observed at the Station, Thissell's Free ripens about with Garey's Hold On and Crimson Beauty. The last named is usually considered as belonging to the Smock season, and the Hold On to a period ten days later; in fact, so late as to be of little or no value in the coast districts.

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But Beer's Smock and Smock's Late Free ripened within two or three days as early as Thissell's Free or Garey's Hold On, while Wilkins' Cling and Salway came in still later, October 1st, and no less than four varieties, Bonanza, Wager, Ward's Late Free, and Henrietta, ripened fruit on October 2d. Continuing in order of ripening, we have at Amador Station, George's Late Cling, October 6th; then General Bidwell, October 27th; lastly, Bilyeu's Late, October 29th and until November 4th.

From the standpoint of the valley fruit-growers this order of ripening is almost incomprehensible. This can best be illustrated by parallel columns, showing the leading late varieties:

Order of Ripening at the Station.	Order of Ripening in Alameda County.
1. Seller's Cling.	1. Morris White (4th in station list).
2. Heath Cling.	2. Stump the World (9th in station list).
3. Mrs. Brett.	3. Thissell's Free (10th in station list).
4. Morris White.	4. Seller's Cling (1st in station list).
5. Nichol's Cling.	5. Nichol's Cling (same as in station list).
6. McDevitt's Cling.	6. Lovell (8th in station list).
7. Picquett's Late.	7. General Bidwell (16th in station list).
8. Lovell.	8. Ward's Late Free (15th in station list).
9. Stump the World.	9. Picquett's Late (7th in station list).
10. Thissell's Free.	10. Smock's Late Free (12th in station list).
11. Garey's Hold On.	11. Salway (13th in station list).
12. Smock's Late Free.	12. Mrs. Brett (3d in station list).
13. Salway.	13. Heath Cling (2d in station list).
14. Wilkins' Cling.	14. Wilkins' Cling (same as in station list).
15. Ward's Late Free.	15. McDevitt's Cling (6th in station list).
16. General Bidwell.	16. Garey's Hold On (11th in station list).
17. Bilyeu's Late.	17. Bilyeu's Late (same as in station list).

This is certainly a striking illustration of the climatic differences between districts of California. The ordinary lists of peaches for home orchards, as well as for commercial purposes, as planted in the valleys, would be entirely unfit for the mountains. If one could plant but six peach trees in such districts as that in which the Station is situated, Mr. Hansen recommends the following: Briggs' May; Foster, or Early Crawford; Elberta, or Muir; Nichol's Cling; Henrietta; Garey's Hold On. For a large home orchard, he recommends the following list, for order of ripening and high-grade quality: Alexander, Shumaker, Strawberry, Hale's Early, Tuskena Cling, Foster, Chinese Cling, Royal George, Honey Cling, Elberta, Muir, Late Crawford, Newhall, Grover Cleveland, Lemon Cling (or Nichol's Orange Cling), Picquett's Late, Indian Blood, Late Admirable, Columbia, Thissell's White, Garey's Hold On, Crimson Beauty, Salway, Wilkins' Cling, Henrietta, George's Late Cling.

This review of the peach orchard might be much further extended, but some important representative varieties must be added, and the granite-soil orchard must also be tabulated hereafter. The most casual student of these reports cannot have failed to observe, however, that especial success has attended the culture of main crop and late peaches of the Southern and European varieties; also that the California seedlings have not always thriven, varieties originating in the coast valleys being perhaps unsuited to the district. Especial preëminence in the finer types of late clings for shipments fresh, or for canning and drying, is indicated by the results of the season. The quality of the fruit ranges from good to best. In size, the mountain peaches, on unirrigated lands, more nearly correspond to Eastern standards, and would rank as small to medium in the valleys of California.

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CEREALS AND HAY.

Expensive experiments with varieties of cereals have not yet seemed advisable at this Station. The mountain farmer raises little grain except for feeding to his stock; the local demand also limits his hay crop. A few standard varieties are all he needs, and the many plots devoted to cereals at other stations would serve no purpose in districts where milling wheats and brewing barleys are not used.

The hay crop is so important locally in the Sierra, where freighting is always expensive, that it justifies much attention from the Station workers. The results of a small trial of fertilizers upon some of the poorest soil on the tract, a light, decomposed granite, were printed in the Report for 1891. In 1892 the experiment was continued under similar conditions, also in 1893.

The following table compiled from data forwarded by Mr. Hansen, will illustrate the conditions. It should be explained that the plots were laid out with a view to obtaining uniform soil. The table covers the three seasons, 1890–91, 1891–92, and 1892–93. The first of these seasons was considered an average year in the neighborhood; rainfall, 18.18 inches. The second season was locally considered an exceptionally good year; rainfall, 28.90 inches. The third season, though it had 40.97 inches of rain, was a poor one in the district. Mr. Hansen wrote concerning it: "The early part of the season was one continuous rain, and the lack of any warm days during that time kept the grain back to an alarming extent. Still, in spite of that, we would have had a fair crop if we could have had late rains. But instead of the usual heavy rains the first week of May, we had hardly any rain at all that month—hence the small amount of hay harvested." Mr. Hansen sowed barley the first season, wheat the second season, and oats the third season upon all the plots tabulated:

Hay Statistics.

	1890-91. (Barley.)		1891-92. (Wheat.)		1892-93. (Oats.)	
	Fertilizer.	Pounds per Acre.	Fertilizer.	Pounds per Acre.	Fertilizer.	Pounds per Acre.
Check-Plot (red soil); area, 9,120 sq. ft.	None.	1,500	None.	1,575	None.	1,750
Plot 2 (pure granite); area, 9,120 sq. ft.	125 lbs. "C" fertilizer.	2,750	50 lbs. bone meal, 35 lbs. nitrate of soda.	5,700	None.	2,200
Plot 3 (one third red soil, the rest granite); area, 18,240 sq. ft.	200 lbs. bone meal and 100 lbs. nitrate of soda.	3,000	150 lbs. br'd C, 50 lbs. bone m'l.	5,900	None.	2,700
Plot 4 (pure granite); area, 18,720 sq. ft.	400 lbs. bone meal.	2,500	75 lbs. nitrate of soda, 150 lbs. brand C.	5,500	None.	2,200
Plot 5 (pure granite); area, 21,120 sq. ft.	225 lbs. nitrate of soda.	2,000	100 lbs. bone meal, 150 lbs. brand C.	3,000	None.	1,100
Days of growth	125		173		167	
Rainfall	18.18 inches.		28.90 inches.		40.97 inches.	
Seed sowed per acre	220 pounds.		180 pounds.		200 pounds.	

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All that was needed to make this table complete was the check-plot on the poorest granite soil, and the uniform use of the same grain for the three seasons. But certain conclusions are indicated. Bearing in mind that the poor granite soil, unfertilized, often does not yield five hundred pounds to the acre, the history of plot 5 is instructive. The crop on it was increased to a yield of a ton of barley hay by the use of about 100 pounds of nitrate of soda; by a little additional help, it went to a ton and a half of wheat hay the second year, and enough was left in the soil to furnish a better yield the third year than any new land of the same sort could possibly produce. It is plain that the bone meal and nitrates pay, and pay largely in the granite soils, as illustrated by plot 2. The yield of nearly three tons of barley hay is about two and a half times the probabilities of the same soil, unfertilized, even in a very favorable season. The irregularity in the comparative amounts of fertilizers used on the different plots in different seasons necessarily prevents any very close comparison of results.

The hay plots laid out in the winter of 1893–94, for the coming season, are of a uniform size of one tenth of an acre.

On the granite soil sixteen separate plots have been sown, five of which are in oats and eleven in barley. Of the plots devoted to oats, the fertilization is as follows: Check-plot, no fertilizer; on other plots, respectively: 50 lbs. bone flour; 20 lbs. potash; 50 lbs. brand "B"; 10 lbs. nitrate of soda. Of the plots devoted to barley, the fertilization covers a wider range. Besides check-plots, the following variations are made: 40 lbs. potash; 50 lbs. bone flour and 10 lbs. nitrate of soda; 50 lbs. dried blood and 10 lbs. nitrate of soda; 60 lbs. bone flour; 50 lbs. blood; 50 lbs. brand "B"; 40 lbs. chicken manure; 50 lbs. bone flour. Some of these are duplicated, to better afford comparisons.

On the red soils ten plots have been laid out, besides the check-plots, three sown to oats, the rest to barley. The fertilizers used on the plots devoted to oats are as follows: 50 lbs. brand "B"; 50 lbs. blood; 40 lbs. potash. The barley plots are fertilized as follows: 60 lbs. bone flour; 40 lbs. chicken manure; 50 lbs. brand "B"; 50 lbs. bone flour and 10 lbs. nitrate of soda; 50 lbs. blood; 40 lbs. potash.

The bone flour used in the above experiments, at this and other stations, was a gift from Mr. J. E. Miller, Manager of the California Fertilizer Works, of San Francisco.

FIGS AT THE FOOTHILL STATION.

By GEORGE HANSEN, Foreman.

The fig plantation at the Station encircles Reservoir Hill, beginning 75 feet above the ditch, rising to 140 feet on the Summit, and descending on the other side to about the same level as the commencement. Seventy-six trees are planted here in avenue shape. Most of them are in the rich, red soil so common throughout the foothills; a few, however, are on the granitic soil, though even here it is improved by receiving the "wash" of the red soil on the higher slopes.

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The oldest trees on the Station were planted five years ago, and many new sorts have been added from time to time. The yearly growth of the trees is from 12 to 48 inches, and the finest looking tree, White Adriatic, now has a trunk 6 inches in diameter, and stands 14 feet high. No water has been supplied from any artificial source.

The annual extremes of temperature at the Station are usually from 21° to 107° Fahr. No branch nor bud has ever been injured by the cold, though all the trees are alike exposed to the cutting north and east winds sweeping with terrible force over the hills at the beginning of the rainy season, and again in the early spring.

The following varieties are represented:

Agen.
Black California.
Black Bourjassotte.
Brogiotto (black).
Breba.
Brunswick.
Col di Signora Nero.
Datto (white).
De Constantine.
Drap d'Or.
Gros Gris Bifere.
Ladara.
Osborne Prolific.
Petrovaca.
Rubado.
Smyrna.
Trojano.
White Adriatic.
Zimea.
Angelique.
Black Ischia.
Black Dattato.
Brogiotto (white)
Brown Turkey.
Cernica.
Damatino (?)
Du Roi.
Early Violet.
Hirtu du Japon.
Monaca Bianca.
Pasteliere.
Rocardi.
Ronde Violette Hative.
Sanvito.
White Ischia.
White Genoa.
Abondance Précoce.
Black Marseilles.
Bourjassotte grise.
Brianzola.
Brown Ischia.
Col di Signora Bianca.
Dalmatian.
Dorée Narbus.
Guiglione.
Kargigna.
Negra Larga.
Ronde Noir.
Smyrna (Bulletin).
San Pedro.
White Marseilles.
White Bourjassotte.

Most of these figs develop their first leaves in the last week of April. Ladara, the earliest, showed leaves April 20th; Pasteliere on April 21st; Black Marseilles, Brown Ischia, Ronde Violette Hative, on April 23d; last of all came Negra Larga, April 30th, and the extremely hardy Dorée Narbus, May 1st.

Comparisons of varieties, always difficult, are especially so at this Station, as but few trees have been planted, and local conditions vary considerably. Nevertheless, the following memoranda may prove of interest:

Statistics of Bearing Ages.—Those figs that bore the first year after being planted were the Du Roi, Petrovaca, Drap d'Or, Hirtu du Japon, and Early Violet.

The following sorts first bore fruit the second year after planting: Pasteliere, White Genoa, Osborne Prolific, Dorée Narbus, and White Marseilles.

In the third year after planting: Cernica, Bourjassotte Grise, White Adriatic, Abondance Précoce, and Ladara.

In the fourth year: White Bourjassotte, Rocardi, Smyrna (from Bulletin stock), and Breba.

Zimea and Angelique, though five years old, have never set any fruit.

Size of Fruits.—Figs of good size have been borne by the Du Roi, Petrovaca, Pasteliere, White Marseilles (see note 1), White Adriatic, and Drap d'Or.

Fruits of fair size are those of the Breba, De Constantine, Gros Gris Bifere, Smyrna (see note 2), Brown Ischia, Bourjassotte (the black, and the green), Brunswick (see note 3), and Hirtu du Japon.

Figs of small size are those of the Col di Signora Bianca, Black Ischia, and the Dorée Narbus.

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Figs so far worthless in this district are the White Ischia and the Black Marseilles.

In the above classification, the expressions "good," "fair," and "small" are only relative, but true up to date. A first-crop Petrovaca fig, picked July 3d, measured 7 by 7½ inches in lateral and longitudinal circumferences. But figs of the later crop measured only 5 by 5½ inches. Monaca Bianca and Brown Turkey were much the same. Such fruits, in this locality, grown without irrigation, can safely be called "large." Du Roi averaged 9½ or 10 figs to the pound; White Adriatic, 8½, and these can be called "fair-sized" for mountain fruit.

Figs that Fell Off.—Breba, reported as losing its fruit at other stations, held part of the crop, though a portion fell off. By August 20th the Smyrna (Bulletin importation) had lost its fruit, and so had the Dorée Narbus; some of the Brown Ischia figs also fell.

First-Crop Figs.—The following varieties entered the winter of 1893–94 with first-crop figs set, and healthy. The numbers, counted on November 28th, are given after each name: Black Bourjassotte, 27; Black Ischia, 18; Black Marseilles, 75; Brunswick, 2; Brown Turkey, 14; Cernica, 13; De Constantine, 27; Du Roi, 22; Hirtu Du Japon, 6; Monaca Bianca, 27; Osborne Prolific, 3; White Ischia, innumerable, and worthless. Similar fruits, set in the autumn of 1892, were ripened into fruit crops by: Black Marseilles, 32; Brown Turkey, 5; De Constantine, 6; Du Roi, 10; Monaca Bianca, 7; Petrovaca, 4.

Foliage.—Some varieties retained their leaves in a green state till November 17, 1893, only dropping them little by little after the frosty gale of that date, when the thermometer fell to 31° Fahr. On New Year's Day, Abondance Précoce, Dalmatian, Black Dattato, Du Roi, Ronde Noir, Sanvito, Trojano, and Brianzola still carried a few leaves.

Figs for Planting.—Notes on the varieties at the stations are necessarily still incomplete, first as to the varieties that bore here, as the trees may behave differently the very next year; secondly, we do not yet have all our sorts in bearing, and lack some varieties grown elsewhere, which we would be glad to obtain, for comparison. Of early figs, the first ripened here in the first week in July. White Adriatic ripened September 4th, and bore till the first week in November. Du Roi has done excellently from the beginning, a choice fruit, bright in color, rich in flavor, sweet in juice. It bore from August 13th till September 12th, yielding 161 fruits. The birds ate fully as many, and a small late crop was set which carried well into the winter. White Marseilles was nearly as good as the Du Roi, ripening August 20th, and continuing till September 12th; total number of figs gathered, 320, and the birds had theirs besides. These were the best white varieties.

The best brown varieties were Drap d'Or, ripening September 1st; lasting till September 12th; crop, 53. Brown Turkey: first crop was excellent; second crop had a rather tough skin and lacked in sugar.

Pasteliere was the best black fig; a deep black fruit with bluish cast, very juicy, flavor rich and sweet. It did not ripen till September 20th, and only bore about twenty pounds. Ronde Noir, ripening at about the same time, also a shy bearer, had deep purple fruits with yellow flesh.

The best bearer of all is Hirtu du Japon, a plump, round, shiny black fruit, lighter in color toward the stem. It ripened about August 20th, and continued till frosts. The crop is so abundant that counting would

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be difficult, and the short branching growth indicates that it would be well adapted to culture in pots or boxes in colder climates.

Early Violet, ripening the first week in August, is a small grayish fruit with a bluish shade. It is sweet and welcome, because of its earliness, but is too small to have commercial value.

NOTES (by C. H. S.).—(1) The White Marseilles is a very small fig, as small as the Black Marseilles, and of much the same shape and quality. It has a coarse, acrid skin; distinctly a second-rate fig. I am inclined to think that Mr. Hansen's White Marseilles must be wrongly labeled. It is probably the Grosse Marseilles, a different sort.

(2) This must be the ordinary "White Smyrna," so called, or California; nearly identical with the Dalmatian of our Tulare Station, and called by John Rock identical with the Brunswick. But what Mr. Rock means is, I think, what has been known as "Brown Smyrna." Under any name, this should be one of the largest figs at the Station, larger than White Adriatic. The Bulletin Smyrna dropped its fruit, as is usual with that variety.

(3) The true Brunswick is one of the largest figs known, only surpassed in that respect by Negra Larga.

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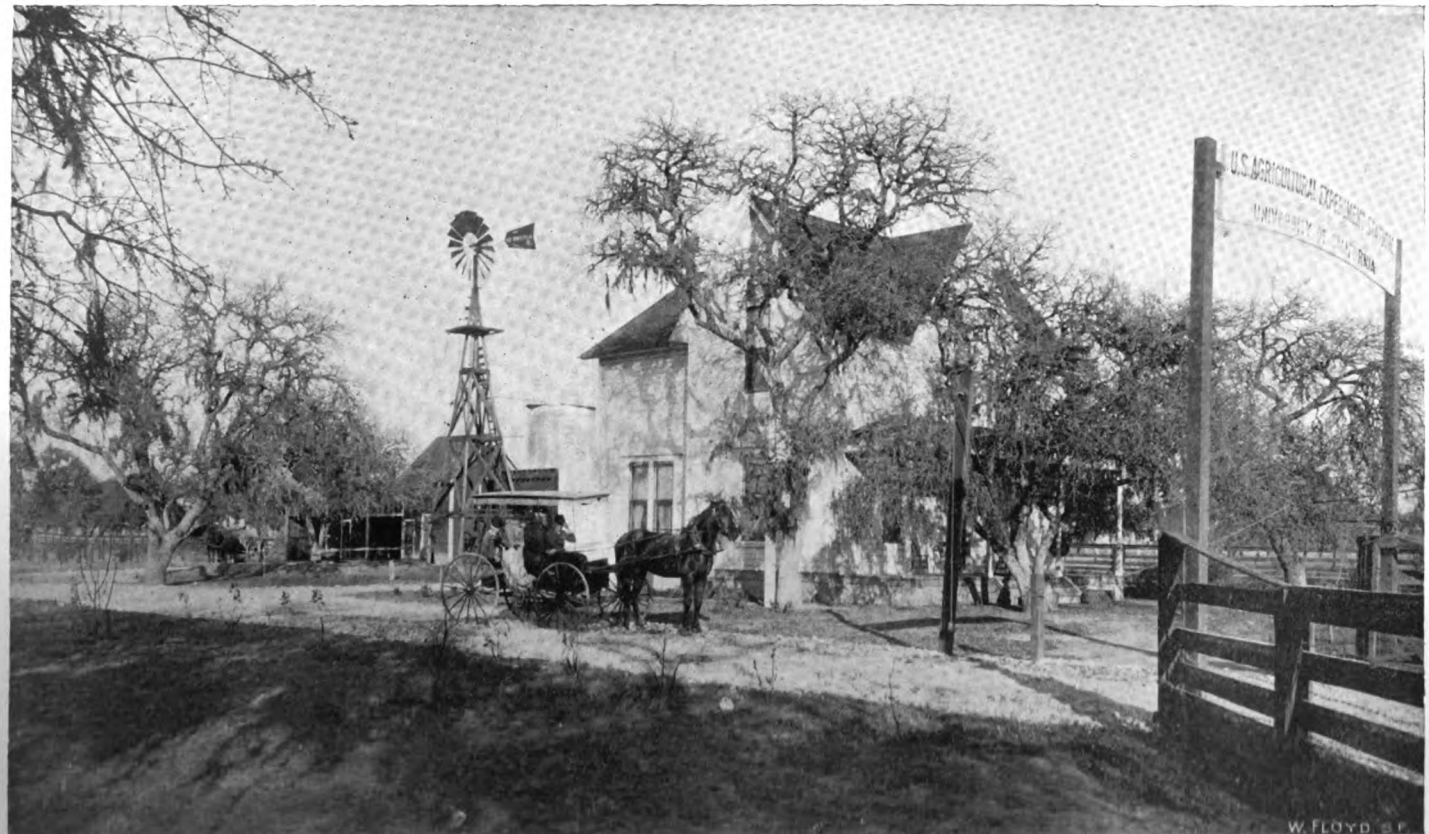

BUILDINGS AT SOUTHERN COAST RANGE EXPERIMENT STATION PASO ROBLES.

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C. SOUTHERN COAST RANGE STATION.

One and a half miles north-northeast from Paso Robles, San Luis Obispo County.

By CHARLES H. SHINN.

General Review of Year's Work.—The season of 1892–93 has been more favorable for plant growth than that of 1891–92. In the Paso Robles district, and in general, I believe, in the hill country of the southern Coast Range, late spring rains are essential to success with annual crops. The orchards, also, need late rains, to give size to fruit. While there is usually rain enough in the district, it does not always come at the best time for the agriculturist. The spring rains of 1893, after March 1st, amounted to 0.88 of an inch, and would have been a greater help had it not been for the long series of drying north winds which began about March 1st and continued till June.

In some seasons the rainfall after March 1st is twice as great, and calm, cloudy weather enables the soil to retain the whole of it. Owing to the north winds the cereals were only an average crop, but the orchards, with deep cultivation, suffered no injury, and made, in fact, a growth surpassing that of any former year.

The climatic table accompanying this report shows the time and severity of the frosts. The coldest nights of 1893 were November 18th and 19th, when the thermometer registered 19° and 20° Fahr. On the 19th, 20th, and 21st of December, 1893, the thermometer registered 22° each night. In the spring of 1892 there was a long period of low temperature, that injured the peach and apricot crop and destroyed the almond and cherry blossoms. The thermometer fell below 34° on sixteen nights in January, seven nights in February, five in March, two in April, and one in May. Nineteen varieties of peach failed to set fruit. The lowest point during the blooming season, March 28th, was 30° and that did the injury.

In the spring of 1893, the thermometer fell below 34° during twenty-five nights in January, seven nights in February, five in March, and three in April, but at the most important period of bloom the temperature fell to 34° on only one occasion. Fifteen of the nineteen varieties of peach that were frosted in 1892, fruited in 1893; but four, Crimson Beauty, Honey Cling, Ulatis, and Strawberry, failed to set fruit, and this may have been due to some frosting of the blossoms.

The summer of 1893 was more temperate than usual, the thermometer going above 100° but once in June, once in July, and twice in August. The highest point reached during the season (July 18th) was 106°. The

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following table shows the temperature at the Station for the fiscal year ending July 1, 1893:

Paso Robles Temperature Report for the Fiscal Year 1892-93.

	Daily Mean.	Mean Daily Max.	Mean Daily Min.	Mean Daily Range.	Extreme Max. and Dates.	Extreme Min. and Dates.
1892—July	74.82°	92.87°	56.80°	36.07°	106° 1, 4, 31	50° 2, 3, 6
August	72.09	92.74	51.45	41.29	110 .....17, 20	45 ....10, 11
September	67.33	85.76	48.90	36.86	98 7	40 .....5, 26
October	58.57	75.93	41.22	34.71	94 3	30 17
November	51.72	69.57	33.87	35.70	85 11	24 25
December	44.67	54.96	34.38	20.48	68 25	22 ....18, 19
1893—January	41.16	56.20	32.12	24.08	65 ..14, 25, 28	24 ....19, 21
February	46.77	57.10	36.35	20.75	69 21	26 2
March	49.38	58.35	40.70	17.65	80 29	30 13
April	52.63	65.46	39.80	25.66	82 22	34 ...7, 8, 13
May	61.67	79.38	43.96	35.42	91 30	36 15
June	64.89	81.63	48.16	33.47	101 2	42 ....13, 19

The vineyard was again touched by early frosts, and late grapes injured. The fruit of the olives was mostly destroyed by severe cold. Places within a mile of the Station do not suffer from the frost. It is a peculiarly trying situation for olives, oranges, figs, walnuts, and the late varieties of grapes. Every year's experience in this extremely variable district gives additional emphasis to the need of care in selecting sites for fruit-growing throughout Monterey and San Luis Obispo Counties. In this extensive and fertile region, 100 miles long by 40 wide, there is a great range of climate, and the local conditions must be studied carefully. Rather slow growth and late bearing of orchards are indicated by our experience at the Station.

It should be remembered, in reading the following report, that the soil on which the orchard is planted is mostly light and dry, called by the San Luis farmers "third-rate land," on which most persons in the district thought that no fruit tree would strike root, or live a year.

Change of Foreman.—At the beginning of 1893, Mr. R. D. Cruickshank resigned the foremanship of the Station, and Professor Wickson, Acting Director, appointed Mr. W. H. Tyson in his place. Mr. Tyson is a Californian of considerable experience as an orchardist, and has already made many improvements in the management of the Station. He moved his family into the farm house early in February, and has given steady and faithful service ever since. It is a decided gain to have a family settled on the place that had so long been managed by two men keeping "Bachelor's Hall," and both house and garden already show many changes for the better.

THE ORCHARD.

There is much of interest in the steady development of the young orchard. It is receiving better culture and more systematic pruning than before, and presents as uniform an appearance as can be expected when the differences in soil and varieties of fruit are taken into consideration. Nearly all the trees have made excellent growths, except a few of the apples and cherries, as will be noted in detail under their respective headings.

Mr. Tyson has made seven charts under date of September 4, 1893, showing the age, comparative size, and variety of every fruit tree in the

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IMPORTED PERSIAN BROAD TAIL RAMS.

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plantation, arranged, of course, by separate orchards or blocks, beginning at the south end of the tract and going north. These charts have been extremely useful in preparing this report. When such charts are duplicated at regular intervals of three, four, or five years, they furnish material for many important comparative studies of orchard growth. Such charts or diagrams, if truthful, even though rudely made, are almost essential to a complete history of the Station, and their value will increase with time as successive series of experiments are begun and completed, varieties discarded, old trees regrafted, and new ones planted.

The various lesser orchards of the Station are planted in a continuous belt along the western side of the tract, beginning at a cross avenue and extending from the main central avenue to the boundary line on the west. Between this orchard tract and the county road, the southern boundary of the Station, there is a small vineyard and a portion of the plot devoted to small cultures. Beginning, then, at the south, the cherry orchard comes first, followed in continuous succession by the almonds, apples, peaches, nectarines, apricots, prunes, plums, and pears. While they follow this order in the main, the desire to put trees of a given variety on light or heavy soil, and various other considerations, has prevented the entire separation of the different species. As planting extends up the slope toward the north, on the heavy adobe soil, the mixed character of the central portion of the orchard will doubtless continue, because varieties now on lighter soils will be duplicated on heavier soil.

Cherries.—As the foreman, Mr. Tyson, notes in his report: "The cherry does not seem very well adapted to the soil and climate; considering this fact, the trees have done well." The extreme dryness of the atmosphere is very much against the cherry in the extensive district east of the Salinas, and while it always deserves a place in family orchards, it is not suited to commercial purposes, except where local conditions materially modify the climate. These conditions may occur wherever the Santa Lucia range is sufficiently broken to admit the sea fogs to cañons facing the valley of the upper Salinas. Well-drained bottom lands along the Naciemiento or San Antonio, particularly in the northern slopes of the cañon, would fulfill these conditions, and they might also exist near Santa Marguerita, but seldom on the high plains east of the river.

Most of the cherry trees in the Station orchard are five years old. The largest of these, Windsor and Pontiac, are seven feet in spread of boughs. Five feet across, however, represents the average of five-year-old trees of such standard sorts as Belle d'Orleans, Napoleon Bigarreau, English Morello, Olivet, Black Eagle, Knight's Early, Lewellyn, Lincoln, and Reine Hortense. Between the two grades in size are Burr's Seedling, Willamette, one of three Purity trees, Early Rivers, Coe's Transparent, and Governor Wood. Poor in growth, hardly three feet in spread of branches, are Centennial, May Duke, and Belle Magnifique, Empress Eugenie and one of the Purity trees. Early Rivers, May Duke, and Yellow Spanish show many dead branches, either on account of pruning at the wrong season or because planted where large oaks had been removed when the orchard was established. Black Tartarian, Thompson's Seedling, Chapman, Oregon, and Rockport Bigarreau are but newly planted.

In all, there were forty-one varieties of cherry represented in this

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orchard at the close of 1893, with three vacancies to be filled by new trees during the present planting season.

The following table, compiled from Mr. Tyson's memoranda, gives some statistics of the cherry orchard, and serves to illustrate the climatic conditions:

Comparative Table of Cherries—1893.

Variety.	First Flower.	Full Flower.	Blooming Season.	When Ripe.
Belle d'Orleans	March 20	March 31	25 days.	June 8
Belle Magnifique	April 12	April 30	.....	No fruit.
Burr's Seedling	March 28	April 12	20 days.	June 15
Black Eagle	April 1	April 20	25 days.	June 15
Black Mastodon	No blossoms.			
California Advance	April 8	April 18	20 days.	No fruit.
Centennial	April 5	April 19	25 days.	June 20
Cleveland Bigarreau	March 31	April 20	30 days.	June 1[illegible]
Coe's Transparent	April 16	April 25	30 days.	June 1[illegible]
Duchesse de Palluau	April 8	April 20	30 days.	No fruit.
Early Rivers	April 5	April 20	25 days.	No fruit.
Empress Eugenie	April 12	April 20	30 days.	June 15
English Morello	April 19	May 3	18 days.	No fruit.
Governor Wood	April 5	April 20	30 days.	June 15
Great Bigarreau	April 4	April 19	25 days.	June 15
Guigne Trés Précoce	March 28	April 5	20 days.	No fruit.
Knight's Early	April 5	April 18	20 days.	June 20
Lewelling	April 16	April 25	18 days.	June 20
Lincoln	April 5	April 20	25 days.	June 10
May Duke	April 8	April 20	20 days.	June 10
Major Francis	April 5	April 18	30 days.	June 15
Olivet	No blossoms.			
Pontiac	March 31	April 5	30 days.	June 15
Purity	March 31	April 16	20 days.	June 15
Reine Hortense	April 12	April 20	20 days.	No fruit.
Schmidt's Bigarreau	April 16	April 26	.....	No fruit.
Tradescant Black Heart (1)	March 20	March 31	28 days.	No fruit.
Tradescant Black Heart (2)	April 4	April 20	.....	No fruit.
Werder's Early Black	No blossoms.			
Willamette	April 4	April 16	26 days.	June 10
Windsor	March 28	April 5	20 days.	June 15
Yellow Spanish	April 16	April 25	20 days.	No fruit.

The age of the trees tabulated above is uniformly five years, except in the cases of Centennial, Reine Hortense, Tradescant's Black Heart, Willamette, and Warder's Early Black, which were four years of age. The amount of fruit set was very small in every case, and hence the weight was not determined. All the trees, except Yellow Spanish and Early Rivers, as noted, made fair or even good growth. The foreman notes the firmness of the large, mottled Centennial cherry; the similarity of Coe's Transparent, Purity, and Governor Wood; also that of May Duke and Empress Eugenie. Major Francis resembles the Burr Seedling; Windsor is like Napoleon Bigarreau in shape, dark-red color, excellent quality; the Cleveland Bigarreau is somewhat the same as the Napoleon, and does not seem better. Willamette, a black, round cherry of medium size and good quality, promises to rank well. Lewelling belongs to the Black Republican class, and does not differ greatly from the type form.

In the above table one notes that one Tradescant's Black Heart and the Belle d'Orleans bloomed first (March 20th); Coe's Transparent, Yellow Spanish, Schmidt's Bigarreau, and the Morello were in fair growth; the others were poor trees, so that their blossoming time was probably abnormal.

The time of full flower, a better comparison, varied thirty-three days from Belle d'Orleans (March 31st) to English Morello (May 3d). The

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length of the blooming season varied considerably, from the eighteen days of the Morello to the thirty days of the Pontiac, Governor Wood, and no less than five other varieties. The time of ripening covered a season of but twelve days, from June 8th to June 20th. The same varieties in Alameda County would extend over a period of about thirty days. Although this curiously short season at Paso Robles will be lengthened as larger crops are borne, such a collection of varieties in the coast climate would give a much wider range, even the first bearing year. Eleven varieties, however, some of them among the latest, "set no fruit," and it remains for another season to determine the length of the cherry season at the Paso Robles Station.

Almonds.—The foreman reports that "all the almond trees grew exceedingly well, those old enough to bear producing heavily, except the Commercial, which bloomed so early that the blossoms were injured by frost. The I X L is far ahead of any of the other soft-shells now bearing at the Station, and seems in every way adapted to the soil, and hardy enough to stand considerable frost. The I X L nuts were large, well-filled, and uniform, and very bright in color, even before bleaching. It ripens early in the season, being the earliest of all the varieties at the Station, and the husks open well in the latter part of August. Of the soft-shell almonds, the Paper-Shell is next in size of tree to the Sultana; the nut is larger, and preferable on that account; the yield of both is about equal. The only hard-shell bearing at the Station is Bidwell's Mammoth, which bore very well for a four-year-old tree. The nuts are rightly named, for they are certainly of immense size."

The largest almond trees in the orchard are I X L, Sultana, Nonpareil, King's Soft-Shell, Bidwell's Mammoth, Texas Prolific, and Drake's Seedling. The last three are but four years old; the others are five, but all show a circle of boughs over a circle of nine feet in diameter, and all, in general appearance and healthiness, would be thought fine almond trees anywhere. Of lesser growth are Marie Dupreys, Harriott's Seedling, Ne Plus Ultra, Golden State, Languedoc, and Pistache. Still smaller for its age is another Drake's Seedling that stands where one of the ancient oaks was removed. Fifteen varieties of almonds are represented in the orchard. Besides, there are twenty seedlings in orchard form, planted by the late Mr. Klee, who took especial pains to select the stock, but whether cross-fertilized or not, we have no record. These trees can be used to graft new sorts upon, leaving enough of each original tree to test the quality of the seedling.

Comparative Table of Almonds—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Harvested.	Amount Yielded.
Harriott's Seedling	Feb. 1	Feb. 20	Feb. 26	Mar. 10	28 days	No crop.	.....
Marie Dupreys	Feb. 14	Feb. 28	Mar. 6	Mar. 18	22 days	Aug. 3	4 lbs.
I X L	Feb. 15	Mar. 1	Mar. 1	Mar. 15	20 days	Aug. 30	10 lbs.
Bidwell's Mam'oth	Feb. 18	Mar. 1	Mar. 3	Mar. 16	20 days	Sept. 30	6 lbs.
Ne Plus Ultra	Feb. 15	Feb. 28	Feb. 28	Mar. 12	17 days	Sept. 30	1 lb.
Sultana	Feb. 18	Feb. 26	Mar. 1	Mar. 14	22 days	Aug. 21	8 lbs.
Paper-Shell	Feb. 13	Feb. 27	Mar. 8	Mar. 20	23 days	Aug. 21	4 lbs.
King's Soft-Shell	Feb. 23	Mar. 10	Mar. 10	Mar. 26	23 days	Aug. 21	7 lbs.
Drake's Seedling	Mar. 1	Mar. 13	Mar. 16	Mar. 28	22 days	Sept. 30	3 lbs.
Nonpareil	Mar. 10	Mar. 18	Mar. 10	Mar. 30	20 days	Aug. 28	6 lbs.
Texas Prolific	Mar. 3	Mar. 22	Mar. 24	April 4	22 days	No crop.	.....
Pistache	Mar. 13	Mar. 22	Mar. 25	April 4	20 days	No crop.	.....
Languedoc	Mar. 10	Mar. 18	Mar. 18	Mar. 28	15 days	Oct. 1	A few nuts.

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The variation of date of first flowering in the case of the varieties of almond is considerable, being, as shown in the above table, from February 1st to March 13th, or nearly six weeks between Harriott's Seedling and Pistache. Most of the varieties begin at the Station about the middle of February, and the period of bloom ranges from fifteen days (Languedoc) to twenty-eight days (Harriott's Seedling). The first leaves come out, in most cases, a week after the period of full bloom, or three or four weeks after the first flower appears, but some varieties leaf out while in the prime of flower. The first almond to ripen is Marie Dupreys (August 3d), and the latest is the well-known Languedoc.

Apples.—A few trees have showed stunted growth on a part of the head, but the foreman believes that this will soon be remedied by later pruning than heretofore. White Winter Pearmain and Fall Pippin bore fruit of fair size and good quality this season. Though the summer climate is very warm, the cold winters particularly suit the apple, and the Station is justified in planting a large assortment. A rather slow but compact growth is to be expected in this district—a dry upland region where it is from 80 to 160 feet to water, but good cultivation has nowhere shown better results than in the apple orchard.

Nearly all the trees, except a few replantings, are five years old. The largest in spread of branches are Bledsoe, Red Winter Pearmain, Long, Red Beitigheimer, English Golden Russet, Missouri Pippin, Bledsoe, and Pewaukee. The boughs of these trees cover a circle of between six and seven feet in diameter. The Russet does better than one would expect. The following varieties are a little smaller: Walbridge, Jonathan, Shirley, Shannon, White Astrachan, Beauty of Kent, Lawver, Alexander, Fameuse, Winesap, Vandevere, Flora Bell, Ribstone Pippin, Mann, and Keswick Codlin. Of almost identical size are Swaar, Yellow Newtown Pippin, Mother, MacMahon, Wolf River, Gloria Mundi, and Ladies' Sweeting, all having made trees of almost four feet spread of branches. Still smaller are the trees of Talman's Sweeting, Wagener, Rome Beauty, and Early Strawberry, and these kinds can be said to be unsuitable to the locality. Fifty-two varieties are represented, and there were also four gaps where trees had died, which were to be filled this planting season, making a total of fifty-six varieties in the apple orchard.

The record of the apple orchard shows that the variety that showed the earliest flowers and leaves was Siberian Crab (March 25th) with Stump and White Winter Pearmain following closely on March 28th; Bledsoe showed first leaves on March 31st; then came an interval of four or five days, when Shannon, Red Beitigheimer, Yellow Newtown Pippin, and fifteen others out of some sixty varieties tabulated, were all beginning to show leaves and flowers. Transcendent Crab, Norton's Pearmain, Baldwin, and a few others bloomed on the 10th. Some twenty-eight varieties began to bloom between the 12th and the 16th. Pewaukee and Red Winter Pearmain were the latest to blossom—April 20th.

With the apple, as with the cherry, the flowers begin to show with the leaves and are fairly out by the time of full leafage. The period between first leaf and full leaf is short with the apple—Winesap and Limber Twig took only five days from April 15th, but ten days is more nearly the average period, and White Astrachan required seventeen days.

The earliest apples, such as Red June and Early Ripe, leafed out and blossomed eight days later than such a famous late apple as White Winter Pearmain. On the other hand, two winter apples, Yellow New-

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town Pippin and Red Winter Pearmain showed a difference of sixteen days, and the best keeper is the earliest blossoming fruit. Notwithstanding the similarity of names, the Red Winter and White Winter Pearmain, which bloomed twenty-three days apart, are not related to each other. The Red Winter Pearmain is even known as Red Vandever in Tennessee, and as Red Fall Pippin in the Middle States, and though its origin is unknown, one is tempted to infer Russian Blood in this as in the other early-blooming varieties.

Peaches.—The largest five-year-old peach tree in the orchard is a Mrs. Brett, which is about eleven feet in spread of branches. Other extremely fine trees are McKevitt's Cling, Muir, Lovell, Early Rivers, Foster, Seller's Cling, and Mountain Rose. Nearly equal to these are the Susquehanna, Chinese Cling, Brandywine, Strawberry, General Bidwell, Crawford's Early, and a large number of others. The peach orchard consists of three, four, and five-year-old trees, and is remarkably uniform in growth and quality. Among the poorer growths are Ward's Late Free, Waterloo, California, and Henrietta.

In the orchard there are seventy-three named varieties, besides some duplicates and about thirty seedlings planted by Mr. Klee. Two of these seedlings have now come into bearing. One resembles Crawford's Early, but is much later; the other is of the Muir type, with particularly small pit, and is, as the foreman reports, "the finest peach of its season at the Station." They will, of course, receive further study.

The following tables have been compiled by the foreman for the report:

Comparative Table of Freestone Peaches—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Ripe.	Amt. of Fruit.
Amsden	Mar. 22	Mar. 30	April 5	April 14	30 days.	July 8	30 lbs.
Beer's Smock	Mar. 22	Mar. 30	Mar. 30	April 10	32 days.	Sept. 20	40 lbs.
Belle Bausse	Mar. 13	Mar. 27	Mar. 30	April 8	.....	Aug. 8	.....
Bilyeu's Late	Mar. 13	Mar. 30	Mar. 30	April 10	31 days.	.....	.....
Brandywine	Mar. 10	Mar. 27	Mar. 30	April 10	28 days.	Set no	fruit.
Briggs' May	Mar. 22	Mar. 30	April 4	April 14	32 days.	July 1	40 lbs.
Columbia	Mar. 13	Mar. 27	Mar. 30	April 10	26 days.	Set no	fruit.
Coolidge's Favorite	Mar. 13	Mar. 30	Mar. 30	April 6	30 days.	Aug. 12	30 lbs.
Crawford's Early	Mar. 22	Mar. 30	Mar. 30	April 6	32 days.	Aug. 12	30 lbs.
Crawford's Late	Mar. 13	Mar. 27	Mar. 30	April 6	30 days.	Aug. 30	40 lbs.
Early Rivers	Mar. 16	Mar. 30	Mar. 30	April 8	28 days.	July 20	8 lbs.
Foster	Mar. 16	Mar. 27	Mar. 30	April 6	28 days.	Aug. 16	60 lbs.
George's Late Free	Mar. 13	Mar. 30	Mar. 30	April 10	30 days.	Oct. 2	60 lbs.
Governor Garland	Mar. 22	April 1	April 5	April 14	32 days.	July 1	30 lbs.
Hale's Early	Mar. 22	April 5	April 8	April 14	30 days.	July 20	40 lbs.
Honest Abe	Mar. 16	Mar. 30	April 4	April 14	26 days.	Aug. 15	15 lbs.
Italian Dwarf	Mar. 22	Mar. 30	Mar. 30	April 6	30 days.	Sept. 20	4 fruits.
Lagrange	Mar. 22	Mar. 30	Mar. 30	April 10	30 days.	Sept. 20	6 lbs.
Late Admirable	Mar. 13	Mar. 30	Mar. 30	April 10	28 days.	Sept. 15	10 lbs.
Lovell	Mar. 22	Mar. 30	Mar. 30	April 4	28 days.	Sept. 6	60 lbs.
Morris White	Mar. 22	Mar. 30	Mar. 30	April 6	28 days.	Set no	fruit.
Mrs. Brett	Mar. 12	Mar. 24	Mar. 24	April 10	30 days.	Sept. 1	100 lbs.
Muir	Mar. 22	Mar. 30	Mar. 30	April 10	32 days.	Sept. 1	20 lbs.
Picquett's Late	Mar. 13	Mar. 24	Mar. 30	April 10	30 days.	Sept. 20	20 lbs.
Royal George	Mar. 13	Mar. 27	Mar. 30	April 6	33 days.	Aug. 16	5 lbs.
Salway	Mar. 22	Mar. 30	April 5	April 10	30 days.	Sept. 8	30 lbs.
Smock's Late Free	Mar. 22	Mar. 30	April 5	April 10	30 days.	Sept. 20	40 lbs.
Stump the World	Mar. 13	Mar. 27	Mar. 30	April 6	26 days.	Sept. 20	4 lbs.
Susquehanna	Mar. 16	Mar. 30	Mar. 30	April 10	.....	Sept. 8	50 lbs.
Thissell's White	Mar. 13	Mar. 30	Mar. 30	April 8	25 days.	Sept. 15	20 lbs.
Wager	Mar. 22	Mar. 30	Mar. 30	April 10	32 days.	Sept. 1	20 lbs.
Ward's Late Free	Mar. 13	Mar. 27	Mar. 30	April 6	28 days.	Set no	fruit.
Waterloo	Mar. 22	Mar. 30	April 5	April 14	.....	July 8	8 lbs.
Wheatland	Mar. 16	Mar. 30	Mar. 30	April 10	26 days.	Sept. 1	25 lbs.
Yellow St. John	Mar. 22	Mar. 30	Mar. 30	April 10	30 days.	Aug. 16	40 lbs.

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The earliest ripening peaches on the list are Governor Garland, a white-fleshed peach of fair size belonging to the semi-cling type of the Hale's Early and the well-known Briggs' May. Another excellent early peach, Jennie Worthen, not represented in the table, ripens about the same time—July 1st. All are seven days in advance of Amsden and Waterloo, a few years ago considered among the earliest.

The latest freestone listed is George's Late Free, which ripened October 2d. A variety received under the name of General Bidwell ripened October 20th, the latest peach on the Station, surpassing in this respect Garey's Hold On, Bilyeu's October, and all the clings. The true name of this variety (which is too late for the district, failing to mature before the frosts) remains to be ascertained another fruiting season.

The first blossoming began March 12th, with Mrs. Brett, a September peach, followed swiftly by some eighteen varieties. A little later, between March 16th and 22d, the rest of the peaches began to bloom. From twenty-five to thirty-two days was the total period of bloom. The very early peaches, such as Briggs' May, Amsden, and Governor Garland, did not begin to blossom till March 22d, nine or ten days later than the first bloomers. Nevertheless they took the longer period of thirty-two days to complete their blooming season. There is a suggestion of undeveloped possibilities in such facts. If Briggs' May, which began to bloom March 22d, had blossomed March 12th, with Mrs. Brett, but had matured with its own usual rate of speed, it would have ripened ten days earlier than before. Again, if blossoming with Mrs. Brett it had adopted the short blooming period of Thissell's White, and then proceeded to grow and ripen according to the usual plans of Briggs' May, it would have shortened its season seven more days. It looks as if the horticulturist could hope to have a peach as good as the early types, and not less than seventeen days earlier than any now known; either this or peaches of better quality, because blossoming earlier, and having more time to mature before the usual Briggs' May and Alexander season.

Comparative Table of Clingstone Peaches—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Ripe.	Amount.
Albright's Cling..	Mar. 13	Mar. 27	Mar. 30	April 8	30 days.	Sept. 8	25 lbs.
Chinese Cling....	Mar. 22	Mar. 30	April 5	April 12	32 days.	Aug. 16	40 lbs.
California Cling..	Mar. 13	Mar. 27	Mar. 27	April 6	28 days.	Sept. 8	30 lbs.
Heath Cling	Mar. 13	Mar. 30	Mar. 30	April 6	32 days.	Aug. 12	30 lbs.
Large White Cling	Mar. 13	Mar. 27	Mar. 30	April 8	30 days.	Sept. 1	40 lbs.
Lemon Cling.....	Mar. 18	Mar. 27	Mar. 30	April 10	26 days.	Aug. 28	25 lbs.
McKevitt's Cling.	Mar. 13	Mar. 28	Mar. 30	April 14	30 days.	Sept. 10	20 lbs.
Nichol's Orange Cling.....	Mar. 22	April 3	April 8	April 14	30 days.	Sept. 8	10 lbs.
Newington Cling.	Mar. 13	Mar. 27	Mar. 30	April 10	30 days.	Sept. 20	40 lbs.
Oldmixon Cling..	Mar. 13	Mar. 30	Mar. 30	April 6	28 days.	Aug. 12	12 lbs.
Runyon's Orange Cling.....	Mar. 13	Mar. 27	Mar. 30	April 8	30 days.	Sept. 8	60 lbs.
Seller's Cling.....	Mar. 13	Mar. 27	Mar. 30	April 10	20 days.	Sept. 10	30 lbs.
Tuscany Cling	Mar. 16	Mar. 30	April 1	April 8	28 days.	Aug. 22	30 lbs.
Wilkins' Cling	Mar. 16	Mar. 27	Mar. 30	April 8	28 days.	Sept. 20	few fruits

Nearly all the peaches listed in the two preceding tables were entirely free from curl-leaf during the season of 1893. The only bad cases of curl-leaf were on the Large White Cling, Oldmixon Cling, Italian Dwarf, and Lagrange. A little curl-leaf, not enough to injure the crops, was

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noticed on the Oldmixon Free, Crimson Beauty, and Thissell's White. No other disease was visible on fruit or trees.

Mr. Tyson recommends for the Paso Robles region the following varieties: For early sorts, Briggs' May, Alexander, Amsden, and Hale's Early. For main crop (freestone), Foster, Early Crawford, Honest Abe, Muir, Lovell, Susquehanna, Mrs. Brett, and Picquett's Late. The clingstones that have done best are the California, Albright's, Runyon's, Grover Cleveland, and Heath. The most vigorous trees in the orchard are the Mrs. Brett (freestone). Though the color is somewhat against it for commercial canning, it makes a fine looking dried fruit, and is excellent for table use.

Three seedlings produced at the Station, and fruiting for the first time last season, are worthy of note. First, a large yellow cling, ranks with the best, and the tree is of most sturdy growth. The second is a yellow freestone, much later than the Early Crawford, and of better quality than the Late Crawford. The third is somewhat of the Muir type, the best peach of its season at the Station. It is hardly necessary to say that in the multiplicity of varieties of peaches, great care will be taken to avoid introducing anything that is not a distinct improvement. There are about thirty seedling peaches still to come into bearing and to be worked over as may seem desirable.

Nectarines.—No fruit seems better adapted to the locality than the nectarine, and several new sorts are to be added to the orchard. The largest nectarine tree at the Station, five years old, is now about nine feet in spread of branches; Victoria, Early Newington, and Boston, the latter four years old, are eight feet across the branches. Five other varieties represented have made a fair growth, considering the soil. No curl-leaf appeared on any of the nine varieties except the Downton.

Comparative Table of Nectarines—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	When Ripe.
Duc de Vitry	Mar. 13	Mar. 27	April 4	April 16	Aug. 10
Hardwicke	Mar. 13	Mar. 27	April 4	April 16	Aug. 30
Early Newington	Mar. 13	Mar. 31	April 4	April 20	Aug. 25
Lord Napier	Mar. 13	Mar. 31	April 4	April 14	Aug. 21
Downton	Mar. 13	Mar. 27	April 4	April 14	Aug. 26
Victoria	Mar. 21	April 1	April 4	April 14	Sept. 1
Boston	Mar. 21	Mar. 31	April 5	April 16	Sept. 1
Boston White	Mar. 13	Mar. 31	April 5	April 20	Aug. 16
Stanwick	Mar. 21	Mar. 31	April 4	April 16	Sept. 8

According to this table most of the nectarines began to blossom March 13th, only three varieties waiting until eight days later. From ten to fourteen days were required to bring the trees into flower. The first leaf appeared from three to eight days later; in fact, every variety showed leaves on the 4th or 5th day of April, and at a date ranging from the 14th to the 20th all were in "full leaf." It would be difficult to choose nine varieties of peaches whose times of blossoming showed so little variation as is the case with these nine nectarines. Even in time of ripening the period is narrow, only from August 10th to September 8th. Doubtless the nectarine season could be extended to as great length as the peach season, by the same process of selection, and earlier varieties would have a higher commercial value.

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The yield of the four- and five-year-old trees was most excellent. Early Newington bore sixty pounds of large fruit, Downton yielded thirty, Boston White forty pounds, and the other varieties sufficient to test quality. Boston fruit, yellow through to the pit, was called "poor and bitter," but may improve as the tree ages. Hardwicke, white-fleshed fruit, was of "only medium quality"; the other seven were excellent, and Victoria was particularly fine. Early Newington is a cling, the others are freestones. Varieties such as Boston White, which, nearer the coast, are often only a dull green, are of good color and firm texture at Paso Robles.

Apricots.—The collection of apricots is very fair, and has been increased this season by Spark's Mammoth, King, and several more seedlings of promise. The Hubbard, Gold Dust, and Flickinger, planted last year, have made a good growth. The largest tree in the orchard is a five-year-old Smith's Triumph, a Vacaville seedling, whose branches spread over a circle nine or ten feet across. Most of the apricots, however, are planted on very shallow soil at the edge of a swale, and have made poor growth. Those on deeper soil have done well, and there is every reason to call the apricot a marked success in the district. The following illustrative table should be studied in connection with the peach and nectarine tables:

Comparative Table of Apricots—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Ripe.
Alberge de Montgamet	Mar. 10	Mar. 22	April 1	April 10	20 days.	July 11
Blenheim	Mar. 13	Mar. 22	April 1	April 8	20 days.	July 29
Kaisha	Mar. 13	Mar. 22	April 1	April 12	22 days.	No fruit.
Luizet	Mar. 10	Mar. 22	April 1	April 12	15 days.	July 14
Moorpark	Mar. 14	Mar. 26	April 6	April 16	20 days.	July 26
Newcastle	Mar. 13	Mar. 22	April 4	April 14	15 days.	July 6
Peach	Mar. 13	Mar. 22	April 1	April 10	15 days.	No fruit.
Royal	Mar. 11	Mar. 22	April 1	April 12	20 days.	July 18
Smith's Triumph	Mar. 13	Mar. 22	April 1	April 12	20 days.	July 24
St. Ambroise	Mar. 11	Mar. 20	April 1	April 10	15 days.	July 13
Turkey	Mar. 10	Mar. 22	April 1	April 10	15 days.	No fruit.

The earliest blossoms appeared on the Turkey, Luizet, and Montgamet (March 10th), but since Moorpark was only four days later, the beginnings were nearly the same. The range of time in the full period of bloom was much more noticeable—Turkey occupied thirteen days and Kaisha twenty-two days. The season of ripening, particularly when compared with the peaches, is unusual. The Newcastle was not fit for market until a week after Briggs' May peach, and all the eleven varieties tabulated were ripe within twenty days after July 6th. As in the case of the cherries, the climate shortens the fruit's range of season, and renders a small list of varieties necessary to cover the time between the earliest and the latest. The records of an Alameda County orchard in 1893 showed that shipments of several varieties ripening between Montgamet and Moorpark were made from July 11th to August 17th, a period of thirty-seven days. The Montgamet-Moorpark period at the Station, according to the above table, is but fifteen days, and fifteen varieties would amply cover it.

According to Mr. Tyson's notes, Luizet, Royal, Blenheim, and Smith's Triumph bore fairly well. The fruit of the last-named variety was very large, and resembled the St. Ambroise. Alberge de Montgamet, St.

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Ambroise, and Moorpark bore a little fruit. All the apricots produced were of high color and flavor, free from rust or blemish.

There are twenty seedling apricots in orchard form, planted by Mr. Klee for stock, and in hopes that some might prove valuable, as the pits were very carefully chosen.

Plums and Prunes.—Most of the plums and prunes have grown fairly well, excepting those planted on the shallow soil of the southern verge of the swale, the poorest part of the orchard. Some trees here are stunted in growth and practically worthless. There is better ground, and they will be reset.

Among the varieties that have made excellent growth are Smith's Orleans, Ives' Autumn Gage, Bradshaw, German Prune, Royal Hâtive, St. Martin's Prune, Peach, and Shropshire Damson. First-class plum trees, four and five years old, on this soil, without irrigation, have made trees whose branches cover a circle of five to six feet in diameter—not more. Myrobalan seedlings of corresponding ages cover a circle of seven to eight feet across. The following varieties of similar ages have made poor growth, two feet diameter of the top being all they can show: Belle de Septembre, Satsuma, Damas Noir, Yellow Egg, Victoria, Autumn Gage, Simon, Drap d'Or d'Esperen, and Red Magnum Bonum. There are nineteen seedling plums, large Myrobalan, both yellow and red, to be top-worked hereafter.

The following table shows some details respecting the older part of the orchard:

Comparative Table of Plums and Prunes—1893.

Variety.	First Flower.	Full Flower.	First Leaf	Full Leaf.	Blooming Season.	Amount of Fruit.
Botan (Japan)	Mar. 18	Apr. 4	Apr. 4	Apr. 14	30 days.	8 pounds.
Botankio (Japan)	Mar. 18	Apr. 4	Apr. 10	Apr. 24	30 days.	.....
Burbank (Japan)	Mar. 22	Apr. 1	Apr. 4	Apr. 14	.....	*
Chabot (Japan)	Feb. 13	Feb. 27	Feb. 27	Mar. 12	27 days.	Set no fruit.
Kelsey (Japan)	Feb. 27	Mar. 10	Apr. 1	Apr. 10	40 days.	15½ pounds.
Ogon (Japan)	Feb. 14	Feb. 27	Mar. 8	Mar. 20	28 days.	Set no fruit.
Bavay's Green Gage	Apr. 14	Apr. 22	Apr. 18	Apr. 24	16 days.	25 pounds.
Bryanstone	Apr. 14	Apr. 24	Apr. 20	Apr. 30	.....	12 plums.
Coe's Golden Drop	Apr. 10	Apr. 20	Apr. 22	Apr. 30	20 days.	23 pounds.
Czar	Apr. 16	Apr. 26	Apr. 22	Apr. 30	16 days.	11 pounds.
Damson	Apr. 3	Apr. 24	Apr. 22	Apr. 30	20 days.	20 pounds.
Early Golden	Apr. 4	Apr. 16	Apr. 12	Apr. 20	20 days.	10 pounds.
Imperial Gage	.....	.....	Apr. 16	Apr. 24	.....	40 pounds.
Jefferson	Apr. 4	Apr. 14	Apr. 16	Apr. 22	22 days.	20 pounds.
Oullin's Golden	Apr. 12	Apr. 28	Apr. 16	Apr. 28	20 days.	20 pounds.
Peach	Apr. 18	Apr. 30	Apr. 18	Apr. 28	.....	6 pounds.
Précoce de Berthold	Apr. 12	Apr. 20	Apr. 18	Apr. 30	20 days.	25 pounds.
River's Early Prolific	Apr. 12	Apr. 22	Apr. 16	Apr. 22	16 days.	8 pounds.
Bulgarian Prune	.....	.....	Apr. 15	Apr. 25	.....	A few prunes.
Datte de Hongrie	.....	.....	Apr. 12	Apr. 22	.....	A few prunes.
German Prune	Apr. 12	Apr. 24	Apr. 18	Apr. 24	.....	A few prunes.

* Fruit eaten by squirrels.

Mr. Tyson's memoranda of the plum orchard contain the following: "Six varieties of the Japanese plums bore good crops. They have one advantage here over other kinds: they cling to the tree long after becoming ripe, and keep in a fair state of preservation for weeks. The tough texture of the flesh of most of the varieties makes it possible to ship them long distances. The best in quality were the Burbank and the Kelsey Japan.

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"Nearly all varieties of prunes grew well last season. The French prune, Robe de Sergent, and Tragedy matured well, and would have made a fine dried prune. The 'Oregon Silver prune' is a strong, vigorous tree planted on south side of swale; the prunes, some seven or eight in number, were large and of fine flavor. The Barry prune, though not so sweet as the above, is a fine, large, blue and rich prune, a freestone, and a good bearer."

Pears.—Many of the pears are on excellent soil for this fruit, though some suffer from "hardpan." The finest trees, Flemish Beauty and Colonel Wilder, are seven feet or more in spread of boughs. Other trees that have made very satisfactory growth are the following: Madeleine, Forelle, Mount Vernon, Beurré d'Amanlis, Vicar of Winkfield, and Howell. The poor trees of the orchard of eighty-six trees are Anne Ogereau, Duchesse d'Angoulême, and Easter Beurré. About sixty varieties of pears are represented, and in a year or two the orchard will begin to make a showing. There are twenty-five fine Japanese pear seedlings. In 1893, LeConte was the first variety to leaf out at the Station (March 18th); Keifer and Clapp's Favorite came next (March 30th and 31st). Nearly all the pears began to show leaves between the 1st and 13th of April, and all were in full leaf by April 30th.

Olives.—The olive trees are planted on the north, the west, and the south sides of the tract, and are growing very well indeed. It is necessary to send only large and well-rooted olives to this district; small trees are difficult to establish. Rarer and more expensive sorts not yet in nursery are being propagated at the Central Station by budding, grafting, or inarching, according to the variety. The early frosts of the district render it probable that the crop will sometimes be lost, even when the trees are quite large. Mr. Tyson's memoranda upon olives will be found incorporated into a separate report upon the olives at all the stations.

Walnuts.—The climate is very hard on all varieties of the English walnut. Nine varieties were represented here in 1889, and only three are now alive, in spite of good cultivation. Mayette and an English seedling "have made a fair growth," and the trees are very symmetrical. Præparturiens make little growth and seem to be failing in vitality.

Chestnuts.—One of the two Italian chestnuts planted in 1889 died last summer, and the other grows very slowly. They are too near to a group of oaks, but in any case the tree is unsuited to the light soil, and could only succeed in the swale or on the southern slopes beyond.

Quinces.—The locality appears to be too dry to make good fruit without irrigation. Under thorough cultivation the trees made a small growth, but the fruit was worthless.

Mulberries.—All of the varieties of mulberries do extremely well. The slowest growing kind is the Persian, but even this variety has outgrown most of the orchard trees of the same age. It bears heavily and for a long time. The Nagasaki is much the strongest grower, and can be recommended as one of the shade and avenue trees for the district. The branches of the largest mulberry trees now cover a circle fifteen feet in diameter. At the proper season the Station can make local distributions of cuttings of several excellent varieties, such as Lhoo, Nagasaki, White, Italian, Russian, and Persian. All the mulberries root easily from cuttings, and farmers from the uplands of Monterey and San Luis Obispo counties visiting the Station in winter should secure an assortment.

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Figs.—The fig problem continues to be perplexing. The varieties planted in the swale when the Station was established were frozen to the ground so many times that the attempt to maintain the entire fig avenue had to be abandoned two years ago. Some of the figs on higher ground did better, though often injured by frost, and now seem comparatively safe. The late frosts usually destroy the first crop, and early frosts injure the young wood so that the trees gain but slowly. Black Bourjassotte, Angelique, Dalmatian, and White Ischia bore a fairly good main crop. The fruit was medium in size, but of excellent quality. Pollen of the wild or Capri fig was used to impregnate the Smyrna fig, but all the fig pollen of last spring was poor, and generally failed to fructify, though used by several experienced pollinators at various places in the State. The varieties of figs lost at the Station have been replaced on less frosty ground.

THE VINEYARD.

There has been a good deal of trouble about nomenclature at this Station, owing to careless handling of cuttings sent here several years ago, but as the grapes are studied corrections are being made, and the faulty vines in the rows grafted over. The new vineyard of Persian and Italian grapes is excellent in this respect, and in a year or two all trouble in the older vineyard will be at an end. This new vineyard contains seventeen rows of twenty-five vines each, at the southwest corner of the Station tract, on sandy soil. The old vineyard, occupying about one sixth of the Station tract, the central third of the eastern half, can only be extended toward the north into the swale where the soil becomes heavier. Full reports upon the vineyards at all the Stations will be found elsewhere in this volume.

SMALL FRUITS.

The problems involved in small fruit culture on the lighter soils of the dry upland are very serious. Without irrigation, strawberries cannot be grown, and blackberries and raspberries fail for lack of enough moisture to perfect the fruit. Even if a small crop could sometimes be matured by extra cultivation and sheltering the vines, it would not be practicable for farmers on such land to grow enough for family use. Gooseberries and the new Logan Berry promise better success.

Gooseberries.—The Berkeley set about half a crop; berries good size. Downing's Prolific grew well, and bore a full crop of large berries; Champion grew well, and fruited better than Berkeley. The only care taken of the gooseberries was to shelter them from the extreme heat of the sun by cheap lath frames. The sunburn, which has ruined the gooseberry crop for several seasons, was entirely prevented. The last picking was on June 20th. Bushes made strong growth during the summer. Mr. Tyson states that the first price of the lath frames has been repaid by the crop, and the frames are extremely useful for sheltering young plants, etc. In fact, the ordinary fruit-drying tray so common on California farms is excellent for all such uses.

Logan Berry.—Again the record of this berry is remarkable. It originated in one of the moist Coast Range valleys (Santa Cruz), near the ocean, and yet when taken to the hot, dry upper Salinas, it thrives and perfects its berries. The fruit is large, of uniform size, high color, and

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extremely pleasant flavor. The habit of vine growth most resembles the Black-cap raspberry; the color and flavor of the fruit are suggestive of the largest of red raspberries; the shape and texture of the berry are similar to the more solid blackberries. Mr. Tyson reports that the Logan Berry "bore a full crop." It can be recommended for testing in localities too hot and dry for red currants, raspberries, and blackberries, but, like all fruit, will respond proportionately to more generous soils and a moister climate.

SMALL CULTURES.

Cotton.—The cotton plots were planted April 19th. Four varieties of upland cotton were planted—Poor Man's Relief did much the best. The plants were small, not more than eighteen inches high, but the bolls were said by Southerners who visited the Station to be larger than they had ever seen of the same variety.

Melons, Cucumbers, and Gourds.—The region is called a "good watermelon country." The melons are not large, and late planting is necessary, but the quality is high. Last season some seeds of each variety of melon, cucumber, and gourd were sown in the open ground, and some were started early under glass, in paper boxes; but soil and atmosphere were so dry at the transplanting season, that the seeds sown in the open ground overtook and surpassed the house-grown plants. The only way to handle tender vegetables such as the melons, egg-plant, tomatoes, and peppers, and have them early in this region, is to transplant from under glass to the field before the late rains, and protect each plant, which is expensive and troublesome. It can be done on a small scale, however, for the garden. Where land is irrigated, hot-bed plants need not be put out until the nights are warm.

A dozen varieties of ornamental gourds were planted, but the seed was mixed and only five proved distinct. Seeds of the Dipper and the Nest-egg gourds are often asked for by persons who want rapidly-growing vines.

The Ispahan muskmelon, a new sort obtained by the Agricultural Department at Washington from correspondents in Persia, made a rapid growth, surpassing any other variety. Unfortunately, most of the melons cracked and decayed before ripening. The melon is large, oblong, fine-grained, and white-fleshed. Melons picked at different periods of maturity and laid away to ripen, all decayed before becoming fit to eat. If grown in some other locality, it might prove a good market variety, as the appearance is attractive.

Tomatoes.—Golden Queen, Acme, and Trophy were planted by Mr. Tyson. Late in autumn he protected the vines with lath frames, and kept them alive and growing through the following frosts: November 16th, 26°; November 11th, 27°; November 13th, 27°; November 14th. 28°. But the cold of November 18th, 19°, killed the vines.

Potatoes.—Sixteen varieties planted March 22d; no fertilizers used. Dandy, Peerless, and White Pearl yielded small crop. The climate is too hot and dry for ordinary potato culture on most of the rolling lands east of the Salinas. Mr. Tyson thinks that potatoes can be grown here by heavy applications of well-rotted stable manure, plowed in about February 1st, before planting, and a top-dressing later. Earlier planting will also be necessary.

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Other Vegetables.—Long Orange carrots were very small. Blood Turnip beets a failure. Very dry for snap-beans; Black-eyed and Golden Wax bore fairly. Among garden peas, Fill Basket, Prize Taker, and Alaska bore well.

GRASSES, FORAGE PLANTS, AND CEREALS.

The experiment plots for 1893 were all laid out at the foot of the northwestern slope, but below the adobe soil. A superb collection of grains was the result, one that has not been surpassed by any season's growth at the Station. Mr. Tyson arranged small sheaves of all grains on the walls of the office, where they remained until the opening of the Midwinter Fair. The Commissioner from San Luis Obispo County, Mr. A. M. Hardie, desired this collection for the county display in the Horticultural Building, and he was allowed to use it, labeling of course, "Grown at the Experiment Station of the University of California, at Paso Robles."

Grasses, Clovers, and Forage Plants.—The grasses sown December 13, 1892, by the former foreman, Mr. Cruickshank, came up very poorly. The following species failed to germinate: Panicum bulbosum, Panicum millaceum, Lupinus (two species). The following germinated very poorly, grew feebly, and made no record: Phleum pratense, Bromus Hookerianus, Paspalium dilatatum, Gastridium australe, Festuca ovina, Festuca tenuifolia, Panicum altissimum, Trifolium hybridum, Poa arachnifera, Onobrychis sativa. The following species "started well, but died out," owing to drought and north winds: Medicago lupulina, Trifolium hybridum, Anthyllis vulneraria. Lastly, the following species did well on the new plots, better in fact than on the sandy soil on the south end of the tract: Agropyrum Japonicum, Bromis inermis, Digitaria sanguinalis, Holcus lanatus, Lolium perenne, Agrostis vulgaris, Euchlæna luxuriaris, Phlaris media, Phalaris Canariensis, Lotos tetragonalobus, and Melilotus albus.

Noteworthy in these lists is the failure of the Texas blue grass (Poa arachnifera), which has previously done so well on light soil, also of sainfoin (Onobrychis sativa). The Bokhara clover (Melilotus albus) "remained green all summer" without cultivation—a trying test—"stems three feet high." Wild canary was the most satisfactory of the grasses. Bromis inermis "continued green until very late in the season."

Wheats, Barleys, Etc.—In this district the farmers prefer to plant Propo and Red Sonora wheats. At the Station, besides these varieties, Royal Australian, Snowflake, and Chile are reported by Mr. Tyson as especially satisfactory. The following table will show the results of the cereal plots of 1893. Wheats, barleys, and oats were sown on December 9th and 10th by Mr. Cruickshank; rye sown by him December 11th·

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RESULTS OF CULTURE EXPERIMENTS WITH CEREALS.

Variety.	Headed.	Cut.	Straw.	Head.	Grain per Acre.	Straw per Acre.	Observations.
Wheats.							
Cent'nial Black-Bearded	May 20	June 23	5 ft.	4 in.	1,241 lbs.	1.55 tons.	Tallest variety at Station; yields poorly, but handsome.
Winter	May 20	June 23	4 ft. 4 in.	4 in.			Resembles Centennial.
Four-rowed Sheriff	May 25	June 26	3 ft. 3 in.	3½ in.	1,530 lbs.	1.46 tons.	Kernels small, slightly shrunken.
White-Club Brenner	May 12	June 26	4 ft.	2 in.	1,663 lbs.	1.98 tons.	Dark, oblong kernel, filled fairly.
Hungarian	May 20	June 23	3 ft. 3 in.	4¾ in.	1,980 lbs.	1.50 tons.	Dark, small kernel, slightly shrunken.
Snowflake	May 16	June 23	4 ft.	5½ in.	2,270 lbs.	2.04 tons.	Very desirable sort at Station.
Champlain	May 20	June 23	3 ft. 6 in.	3½ in.	1,843 lbs.	1.58 tons.	Small, red kernel, slightly shrunken.
Egyptian	May 12	June 23	4 ft.	4 in.	1,815 lbs.	1.04 tons.	Sound, full, bright kernel.
Victoria	May 20	June 19	3 ft. 6 in.	4½ in.	1,412 lbs.	1.38 tons.	Small, dark kernel, well filled.
Pringle's Defiance	May 12	June 23	3 ft. 6 in.	4½ in.			A good variety.
Michigan	May 27	June 23	3 ft.	3½ in.	907 lbs.	1.63 tons.	Loose chaff; did poorly; kernel shrunken.
Red Sonora	May 3	June 19	3 ft. 6 in.	4 in.	2,212 lbs.	1.26 tons.	Small kernel, very plump.
Pringle's Best	May 12	June 23	4 ft.	4 in.	2,722 lbs.	2.38 tons.	Large, full, bright kernel.
Bonate	May 20	June 19	3 ft. 3 in.	3½ in.	2,042 lbs.	2.25 tons.	Kernel small, slender, dark.
Indian Winter	May 12	June 19	3 ft. 6 in.	4 in.	1,339 lbs.	1.98 tons.	Shells out too easily; a little shrunken.
Tunisian	May 12	June 23	5 ft.	3 in.	850 lbs.	1.20 tons.	Large, dark kernel, badly shrunken.
Taganrog	May 10	June 19	4 ft. 6 in.	3½ in.	1,616 lbs.	1.97 tons.	Resembles Centennial; kernel dark.
Genesee	May 16	June 19	3 ft. 8 in.	4 in.	1,815 lbs.	.59 ton.	Dark kernel.
Hallet's Pedigree	May 28	June 30	3 ft.	4½ in.	1,020 lbs.	1.81 tons.	Too late for this climate.
California Spring	May 17	June 23	3 ft. 4 in.	3 in.	3,261 lbs.	2.55 tons.	Smutted badly; otherwise did well.
Nonpareil	May 17	June 19	3 ft. 6 in.	5½ in.			A desirable variety.
Thuringian	May 20	June 23	3 ft. 8 in.	3 in.	2,297 lbs.	2.48 tons.	Kernels dark, shrunken.
Red Club or Hedgehog	May 20	June 23	3 ft.	1¾ in.	1,871 lbs.	1.62 tons.	Small red kernel, filled fairly well.
Red Bearded	May 20	June 19	3 ft. 6 in.	2½ in.	1,049 lbs.	1.17 tons.	Loose chaff; slightly shrunken.
Harris from Jasper	May 12	June 19	3 ft. 6 in.	4½ in.	1,531 lbs.	1.98 tons.	Dark kernel.
White Pearl	May 12	June 19	4 ft. 3 in.	5 in.	2,268 lbs.	1.78 tons.	**Plump, bright-colored kernel; did *very* well.**
White Sonora	May 17	June 23					
Indian Three-Months	May 15	June 27	4 ft.	5½ in.	2,722 lbs.	2.26 tons.	Fine, large, white kernel.
Hungarian Brenner	May 20	June 20	3 ft. 3 in.	4½ in.	1,978 lbs.	1.79 tons.	Slightly shrunken; dark.
Nicaragua	May 12	June 23	4 ft. 3 in.	3½ in.	1,815 lbs.	1.58 tons.	Small, dark kernel.
White Elama	May 20	June 23	3 ft. 6 in.	4 in.	2,013 lbs.	1.92 tons.	Kernels rather dark; filled well.
Hallet's Genealogical	May 20	June 26	3 ft. 6 in.	3 in.	1,815 lbs.	2.32 tons.	Kernels large, oblong, slightly shrunken.
Mold's White Winter	May 17	June 19	3 ft.	3 in.			A very poor variety here.
Hybrid Dettel	May 25	June 19	3 ft. 6 in.	3 in.	1,899 lbs.	2.28 tons.	Large, well-filled kernel.
Defiance	May 12	June 19	4 ft. 6 in.	4½ in.	2,325 lbs.	1.97 tons.	Appeared well here.
Hallet's Original Red	May 27	June 30	3 ft.	3 in.	1,103 lbs.	1.30 tons.	Long, dark kernel.
Diehle Mediterranean	May 19	June 19	3 ft. 6 in.	3 in.	2,404 lbs.	2.01 tons.	Matures too late.
Martin's Amber	May 25	June 26	3 ft. 6 in.	4 in.	1,815 lbs.		Inferior quality here.
Petali	May 2	June 14	4 ft.	4 in.	2,155 lbs.	1.88 tons.	Large, dark, full kernel.

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Jonquil	May 2	June 19	4 ft. 6 in.	4 in.	3,062 lbs.	2.12 tons.	A fine, plump, bright kernel.
Red Sonora	May 3	June 19	3 ft. 6 in.	4 in.	2,212 lbs.	1.26 tons.	Sown much in this section.
Palestine	May 5	June 14			1,531 lbs.	1.19 tons.	Kernel oblong, dark, not very full.
Mold's Red Winter	May 25	June 30	3 ft.	3 in.	1,474 lbs.	1.81 tons.	Ripens too late.
Blue Glass	May 12	June 23	4 ft.	3 in.	1,355 lbs.	2.18 tons.	Good for show purposes.
Imperial Circassian	May 20	June 30	4 ft. 3 in.	4 in.	3,113 lbs.	2.72 tons.	Long, slim, bright, full kernel.
Diamond, or Polish	May 12	June 19	5 ft. 6 in.	5 in.	1,616 lbs.	1.63 tons.	Long head.
Russian Bearded	May 12	June 19	4 ft. 3 in.	4 in.	1,483 lbs.	1.98 tons.	Medium full, red kernel.
Greek Atlanti	May 12	June 19	4 ft. 6 in.	4 in.	1,872 lbs.	2.02 tons.	Quite plump kernels.
Frankenstein	May 20	June 30	3 ft. 6 in.	5 in.	2,694 lbs.	2.40 tons.	Dark, fine, large kernel.
Volo	May 6	June 19	4 ft. 9 in.	3 in.	1,701 lbs.	2.02 tons.	Large, dark kernel, fairly plump.
Chiddam	May 20	June 30	2 ft. 10 in.	3 in.			Loose chaff; shells too easily.
Fern or April	May 20	June 23	3 ft. 6 in.	4 in.	1,588 lbs.		Shells badly; very small kernel.
Whittington	May 12	June 19			1,128 lbs.	1.13 tons.	
Nonette Lausanne	May 12	June 23	3 ft. 6 in.	2½ in.	2,262 lbs.	1.53 tons.	Small, plump, dark kernel.
Missoyen	May 12	June 23	4 ft.	3 in.	1,928 lbs.	1.79 tons.	Half club bearded.
Oregon Big Club	May 12	June 23	3 ft. 6 in.	1¾ in.	2,382 lbs.	2.32 tons.	Smutted badly.
Touzelle	May 20	June 23	3 ft. 2 in.	4 in.	1,645 lbs.	1.95 tons.	Filled fairly well; thinned out by squirrels.
Forelle	May 20	June 23	3 ft. 6 in.	5 in.	1,531 lbs.	1.47 tons.	Kernels badly shriveled.
Yellow Noe	May 16	June 23	4 ft. 2 in.	4½ in.	2,467 lbs.	2.49 tons.	Fine, large, bright, well-filled kernel.
Clawson	May 10	June 23	4 ft. 3 in.	4 in.	3,119 lbs.	2.38 tons.	Kernels full and bright.
Imperial Circassian	May 10	June 19	4 ft. 3 in.	4 in.	2,495 lbs.	2.60 tons.	Bright colored kernel; filled well.
Chile	May 10	June 19			3,006 lbs.	1.98 tons.	Filled fairly well; some smut.
Royal Australian	May 6	June 19	4 ft. 2 in.	4 in.	2,807 lbs.	2.04 tons.	A good variety; kernel plump and bright.
Archer's Prolific	May 6	June 19	4 ft.	5 in.	3,516 lbs.	2.18 tons.	Bright, plump kernel.
Barleys.							
Early Black Two-rowed	April 17	June 5	3 ft. 3 in.	3 in.	3,233 lbs.	1.34 tons.	Filled well.
Six-rowed Brenner	May 20	June 14	3 ft.	2 in.	2,609 lbs.	1.70 tons.	A desirable sort; not too late.
Black Six-rowed	May 6	June 7	3 ft. 6 in.	3½ in.	1,892 lbs.	1.53 tons.	Fine, plump kernels.
Hallet's Pedigree Chev.	May 3	June 7	3 ft. 6 in.	5 in.	2,836 lbs.	1.47 tons.	Kernels bright and plump.
Bluish Barley	April 20	June 5	3 ft. 6 in.	3¾ in.	1,276 lbs.	.56 ton.	Plump; no hull.
Nepaul	April 20	June 5	3 ft.	3 in.	1,355 lbs.	.53 ton.	Beardless; plump.
Large Naked Two-rowed	May 3	June 5	3 ft.	4¼ in.	1,418 lbs.	.63 ton.	No hull.
Dept. Agric. No. 2	May 3	June 5	3 ft. 6 in.	4 in.	3,970 lbs.	1.50 tons.	Plump; bright blue color; No. 1 brewing.
Dept. Agric. No. 6	May 3	June 5	3 ft. 6 in.	3½ in.	3,779 lbs.	1.30 tons.	Every way desirable, as above.
Kalina	April 29	June 5	4 ft.	4½ in.	1,644 lbs.	.91 ton.	Quality, fair.
Berkeley Hybrid	April 29	June 5	3 ft. 6 in.	3 in.	1,588 lbs.	1.04 tons.	Beardless; two-rowed; plump, bright kernels.
Scotch Two-rowed	May 2	June 5	3 ft. 6 in.	5½ in.	2,062 lbs.	1.20 tons.	Chevalier type.
Italian	May 3	June 7	3 ft. 6 in.	4 in.	2,779 lbs.	1.55 tons.	
Six-Rowed Winter	May 3	June 5	3 ft. 4 in.	3 in.	1,871 lbs.	.90 ton.	Fair quality.
Carter's Prolific	May 3	June 7	3 ft. 6 in.	5 in.	2,036 lbs.	1.36 tons.	Chevalier type.
Rice or Sprat	May 17	June 14	2 ft. 10 in.	2 in.	1,588 lbs.	1.13 tons.	Ripened too late.
Chevalier	May 5	June 7	3 ft. 4 in.	5 in.	2,382 lbs.	1.30 tons.	Bright, plump; grows well here.

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RESULTS OF CULTURE EXPERIMENTS WITH CEREALS—Continued.

Variety.	Headed.	Cut.	Straw.	Head.	Grain per Acre.	Straw per Acre.	Observations.
Oats.							
Gray from Houdan	June 1	June 19	3 ft.		2,042 lbs.	2.55 tons.	Best white oat grown at the Station.
Bald	May 27	June 14	4 ft.		1,531 lbs.	1.95 tons.	Hull removes easily while threshing.
Oats from Texas	May 6	June 7	4 ft.		1,873 lbs.	1.55 tons.	A good oat here; the first to ripen.
Surprise	June 1	June 14	4 ft. 6 in.		1,616 lbs.	2.29 tons.	Bright kernel; well filled.
White Bolognese	June 1	June 14	5 ft.		2,155 lbs.	2.36 tons.	Not so bright as gray oats, but did as well.
Early from Georgia	May 27	June 19	4 ft. 6 in.		1,815 lbs.	2.32 tons.	Kernel dark; filled fairly.
Canadian	May 27	June 14	4 ft. 6 in.		1,815 lbs.	1.70 tons.	Bright, well-filled kernel.
Black from Coulombieres	June 1	June 19	3 ft. 6 in.		1,361 lbs.	2.46 tons.	Very dark kernel.
Black Tartar	June 1	June 19	3 ft.		1,873 lbs.	1.49 tons.	Poor kernels.
Scotch Hopetown	June 1	June 14	4 ft. 6 in.		1,531 lbs.	2.38 tons.	Large, bright kernel, well-filled.
White Wonder	June 1	June 19	4 ft. 6 in.		2,495 lbs.	2.83 tons.	Grew little after heading out; filled well.
Early August	June 1	June 19	4 ft.		1,758 lbs.	1.75 tons.	Light-colored kernel; filled fairly.
Ryes.							
Spanish Double-bearing	May 5	June 7	4 ft. 3 in.	8½ in.	1,473 lbs.	3.11 tons.	The ryes grew about alike; no milling tests were made.
Perennial Saxon	May 2	June 30	5 ft. 3 in.	6 in.	1,815 lbs.	2.42 tons.	
Excelsior Winter	May 6	June 30	5 ft. 3 in.	6½ in.	2,319 lbs.	1.36 tons.	
Swedish Sand	May 6	June 30	5 ft.	6 in.	1,644 lbs.	1.38 tons.	
St. John's Day	May 2	June 30	5 ft. 3 in.	7 in.	2,319 lbs.	2.89 tons.	
Spelts.							
White Silesian	May 30	June 30	3 ft. 6 in.	6 in.	2,893 lbs.	.99 tons.	The spelts all grew well; the rate per acre includes the chaff, it being impossible to separate it by hand.
Blue-Bearded	May 27	June 30	3 ft. 8 in.	7 in.	2,036 lbs.	1.36 tons.	
Red Emmer	May 27	June 30	3 ft. 4 in.	6 in.	1,475 lbs.	.88 tons.	
White Emmer	May 27	June 30	3 ft. 6 in.	3½ in.	2,098 lbs.	1.26 tons.	
White-Bearded	May 27	June 30	3 ft.	6 in.	2,609 lbs.	*	
Bearded Brown	May 30	June 30	4 ft. 3 in.	3½ in.	1,134 lbs.	1.70 tons.	

*Not weighed.

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The small plots which are used in testing the cereals are all prepared with care, plowed twice, harrowed, then raked smooth. Seed is drilled in; no fertilizers are used; weeds are hoed out. This will explain the high yield, calculated on areas of plots, which are usually twelve feet long by six feet wide. An examination of the table will show that in point of yield Pringle's Best, Chile, California Spring, Jonquil, and Indian Three Months far surpass the popular Sonora. The heaviest yield of oats was given by White Wonder, with White Bolognese coming next. In barleys, Department of Agriculture No. 2 and No. 6 easily lead the rest. Excelsior Winter and St. John's Day ryes are the most productive, and the old White Silesian spelt has no superior.

NOTES ON PRUNING DECIDUOUS FRUITS.

By W. H. Tyson, Foreman Southern Coast Range Station.

A practical knowledge of pruning, it seems to me, is one of the essentials of successful fruit culture, particularly in the department of deciduous fruits. As all the first-rate horticultural authorities tell us, pruning is most important, and yet, as they often warn us, and as even casual observation shows, pruning is easily carried too far, or is wrongly done. No other subject provokes more heated or more frequent discussions at conventions of orchardists, or brings out so many irreconcilable views. Nor is this due entirely to local differences of soil or climate. Fruit-growers of the same little neighborhood very often entertain widely different views in regard to some of the leading principles and many of the details of the operation. One thing, at least, seems certain, that it takes years of practical experience, added to some degree of aptitude and some knowledge of the principles of plant growth, for any one to become a really competent tree-pruner.

Theory and observation alone, though necessary, and indeed invaluable, cannot make one proficient in the handicraft, unless accompanied by much practice with saw and pruning shears. My own experience dates from the year 1877, when, in Alameda County, I planted a small orchard, the annual pruning of which I still direct. Nor need it be taken as evidence of stupidity when I add that though I have been pruning more or less every season since then, I find that continued practice still suggests improvements. The living tree is more and more interesting to me, and its requirements become more and more individual. I am still a student in the schools of pruning.

It is not possible to prune a tree after an ideal model, and then to stereotype that form, in all its details, so as to reproduce it exactly in every successive operation over an entire orchard. One cannot even have an ideally pruned tree as representative of each species of fruit tree. Pruning is not so simple as that, nor so mechanically learned and taught. Different species of trees require different details in pruning; so do different varieties of the same species; so do different individuals of the same variety; even the same trees will require different management as they grow older.

As a rule, the deciduous fruit trees have two different habits of growth: the upright and the spreading. Peaches and apricots are good types

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of upright growers; most of the apples and many pears are spreading, though some of the most upright growers among deciduous fruits are to be found among the pears. The growth of the tree when small is often greatly changed as it becomes mature. In pruning one should endeavor as much as possible to conform to the natural habits of the tree, modifying those habits no more than is necessary to secure the aim of all pruning—better fruit production. Here, at the Experiment Station, I have adopted the oval and the round-head systems of shaping fruit trees, always remembering that in this hot, dry climate, terminal buds must be left low down, and around the tree, in both forms.

It is now generally conceded by California fruit-growers of experience that low heads are much the best. Here, at Paso Robles, there is little or no choice in the matter, as trees with long trunks would suffer greatly from sunburn and borers. In this district, and in all similar localities, I advise even lower heads than are usually seen in orchards—as low, in fact, as trees can be grown, and yet close cultivation practiced. Every foot added to the length of the trunk is also a foot added to the fruit-grower's spraying hose and to his picking ladders.

If a tree is to continue in health and vigor, it must be kept growing. Rainfall and thorough cultivation do their parts, but much depends on the judicious heading back and thinning of branches and leaders. When the soil is poor, the need of severe pruning increases. Trees that grow wood without irrigation on the thin mesa land of this district will grow good fruit if properly managed; in fact, if too great a quantity of fruit is not allowed, the quality of the crop on such land is of the best. As every fruit-grower knows, there are compensations in these things.

Leaving the general aspect, I will now proceed to give in detail the system of pruning as done by me at the Experiment Station, and as recommended by me for similar soils and climates. It will not be out of place, I hope, for me to say a few words in regard to the condition in which I found the experiment orchard at the time of taking possession, in the spring of 1893. As a rule, the trees had been started low enough, but previous pruning had been too uniform. All varieties of fruit, of every species, had been headed back to equal length, and the branches, in my opinion, had been left altogether too close to admit sufficient light and air. Even almond trees had formed no exception to this system. Some of them that had not yet been pruned, I let remain without cutting back, and they are now fine, stocky trees, full of fruit buds and capable of supporting all the nuts they can possibly carry. The pruned almonds made only long, slender, close-set growths of leaders, most of which will have to be entirely cut away this winter (1893–94), leaving the remaining branches of slender growth, and thus delaying full fruitage.

Almonds.—Almond trees are rapid growers. In most parts of California they grow too fast, hence I believe we should not prune any longer than is necessary to shape the tree, for as long as a tree is cut back heavily, so long will it continue to grow wood. As soon as a tree is old enough, it will produce fruit spurs, if not headed back. Having noted the very satisfactory result of letting some almond trees go unpruned last spring in order to obtain fruit buds, I venture to say that there is no need to head back the almond in this section after the fourth year. The only pruning required is to remove interlocking branches and maintain the general shapeliness of the tree. In Alameda County I used to prune almonds until after the sixth year, for trees grew so rap-

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idly on the valley lands there, that the trunk of the tree usually needed strengthening to enable it to support the branches and leaves. When a stocky trunk was secured, the tree was allowed to develop naturally, with light pruning thereafter.

Apricots.—I have pruned apricots at the Station grounds on the round-head system, cutting the leaders back for about two thirds of their length. The apricot tree splits down much easier than other deciduous fruit trees, except, perhaps, the fig. I therefore prune so as to avoid as much as possible those dangerous forks where two branches start from the same point and at the same angle.

It has been observed that the brightest, cleanest, and best flavored apricots grow in the shade of the leaves, on spurs and short laterals which extend from wood of two years' growth. I therefore leave only a few, well-chosen leaders, but I let the spurs extend down to the forks of the lowest branches, only removing from year to year those that have perished. I notice here, at the Station, that the small twigs and fruit spurs of the apricots die back to a considerable degree, but still not as much as in Alameda County, where one had to cut back to some extent every year, giving the bark a chance to heal over, and making room for new fruit spurs. The summer heat is much less intense in Alameda County than here, and the fruit-growers there, and throughout the Santa Clara Valley generally, are able to prune after the California vase-shaped system, running the branches up obliquely from the base, with a slightly convex top. Here, as I have said, the head must be more compact.

Prunes.—This district is planting more prunes, and seems well adapted to this fruit. In such places where the summer temperature often goes above 100° Fahr., I feel sure that prune trees need to be cut back without hesitation year after year. The non-pruning method, as advocated, and often practiced, in the coast districts, will not do here; indeed, I am not certain that it ever does well very long in any one place. Pruned back, and kept small, the tree will carry all the fruit it should, and the quality of the fruit will be superior. I should prune trees of Prune d'Agen every year, confining the fruit spurs to the main branches of the tree, and cutting the leaders back to about two thirds of their original length, with the side branches cut somewhat shorter. In planting a new prune orchard here, I should start the branches only six or eight inches from the ground. Most varieties of plum and prune easily take the round-head form, but a few, of strong upright growth, do best with the oval system. The fruit spurs are on short laterals of old wood.

Apples.—The leaders of the apple trees were usually pruned back fully three fourths this season, leaving laterals well down upon, and around, the sides of the trees. A strong, stocky apple tree is to be aimed at in pruning, for the strain is heavy on the tree in seasons of large crops. The apple bears on spurs and short twigs about the main body of the tree, and carries its crop so well distributed that comparatively little thinning is needed. The small laterals often bear fruit first on young trees; after the trees are in full bearing, the bearing points can readily be confined to the spurs alone.

Pears.—The pear is most suitably pruned with either a round or an oval head, in this climate. That much-praised form, the solid pyramidal, valuable no doubt in moister climates, is as much out of place here as

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the espalier. The pear is a heavy fruit, and size and form are important to its usefulness; hence short, stocky growth of the tree is especially necessary. While pruning after something of the same general scheme as with the apples, I do not head back so much, because of the more upright habit of the pear. Like the apple, this fruit bears on spurs and short laterals, and as in the case of the apples, laterals are to be left until sufficient spurs are developed. Some varieties of pears, and a few of apples, bear in clusters. The fruit buds of these can easily be found, and the system of pruning modified so as to save them.

Cherries.—In cherry pruning, the whole field is peculiarly open to discussion. Some successful growers head back the tree year after year; others stop this pruning after the fifth or sixth year. My own experience leads me to approve the latter method. I have indeed obtained more fruit in pounds from trees cut back every year, but it was at the expense of size, quality, and consequent price. Undoubtedly, also, the exhaustion of the soil was greater, as the trees had to make wood as well as fruit. Still more convincing to my mind was the fact that trees so headed back bled much more gum than those that were allowed more freedom of growth. Cherry culture is still a problem in this district, but I have pruned less severely this winter, in the hope of securing better tops. One should avoid too early pruning of cherries, as it increases the tendency to die back from the cuts. Prune when the buds begin to expand, and the wounds will heal faster. Cherries bear on spurs which grow in clusters the entire length of the branch, on wood of more than one year's growth.

Peaches.—I have found that peaches require great care in pruning, and all the skill one can command. The round, low head that suits the peach here, makes cultivation more difficult, but amply repays the trouble. When a peach tree comes to bearing age, it requires individual study of the bearing buds and laterals. If these are abundant, one can cut off half or two thirds of the new wood; if few, the pruning must be longer to make room for the formation of new fruit buds. It often happens that a little work with pruning shears—cutting off laterals—saves much labor of thinning fruit afterwards, but this is a delicate and difficult operation, and late frosts may make one wish he had left all the fruit spurs on the tree. The longer laterals can be cut back, the dead twigs taken out, and the tree kept well open to the sunlight. Since peaches bear on new wood, it is necessary to keep the tree growing by heading back from time to time, thus renewing the top every few years.

These brief notes upon the pruning of the deciduous fruits at Paso Robles should be studied in connection with the general report upon the Station and the climatic table, which serve further to illustrate the peculiarities of the district. In conclusion: If one will study, while pruning, the objects he wishes to attain, such as symmetry of tree, convenience of cultivation, vigor and strength of trunk and branches, quantity and quality of fruit, and ease of gathering it, without having too many theories of "how to prune," he can grow an orchard pleasing to the sight and gratifying in results.

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D. SAN JOAQUIN VALLEY STATION.

One mile southeast of Tulare City, Tulare County.

By CHARLES H. SHINN.

The work of 1893, even more than that of previous years, has illustrated the great and increasing importance of the Experiment Station of the San Joaquin Valley. Nothing that has been done there up to the present time has had to be undone. The land has been studied with reference to the alkali problems ever since the Station was established. An orchard and vineyard were planted without any gypsum treatment, on portions of the tract so selected as to represent some of the best and some of the poorest land (from the standpoint of the immediate horticultural availability). As the trees on portions of the tract succumbed to alkali, they were replaced, in most cases with other varieties, so as to give further test. Upon a second failure, the conclusion, supported whenever necessary by a soil analysis, has been that the soil needed special treatment for alkali. Having thus produced, on the orchard tract, an orchard that is the natural result of the extremely unfavorable conditions, we are gradually transforming it, and building up, tree by tree, a new and healthy orchard, in which every tree represents care, forethought, study, and labor. The mass of accumulated material upon the alkali problem at this Station, includes, therefore, complete data upon the life history of almost every tree in the orchard, and in fact every plant that has ever been put into the soil.

The first detailed study made upon this Station was published in the combined report of 1888–89. It is instructive, and important to the consideration of the following pages, to quote from this report the view that was then taken of the tract and its management: "The southeast quarter of the tract (of 20 acres) is entirely free from alkali, while a body of strongly alkaline soil occupies about one half of the northwest quarter. On the intervening land there are some spots of the same impregnated to a greater or less degree, such as occur scatteringly elsewhere in the same region. The tract has borne a few crops of grain heretofore, which failed only on the alkali land of the northwest corner." Again, in another part of the same report, is the following: "The vines have been given the grounds practically free from alkali, while the rest of the culture plants have been distributed in a measure in accordance with their known ability to flourish in the presence of obnoxious salts. The treatment of the alkali spots that became visible last season (the winter of 1888) with a proper dose of plaster will probably obviate all trouble save in the worst spots near the northwest corner, where the special experiment of reclamation will be made."

In absolute accordance with these views was the chart of the Station tract published in the above report, and reproduced here.

But after 1889, and until now, there has been a steady rise of alkali

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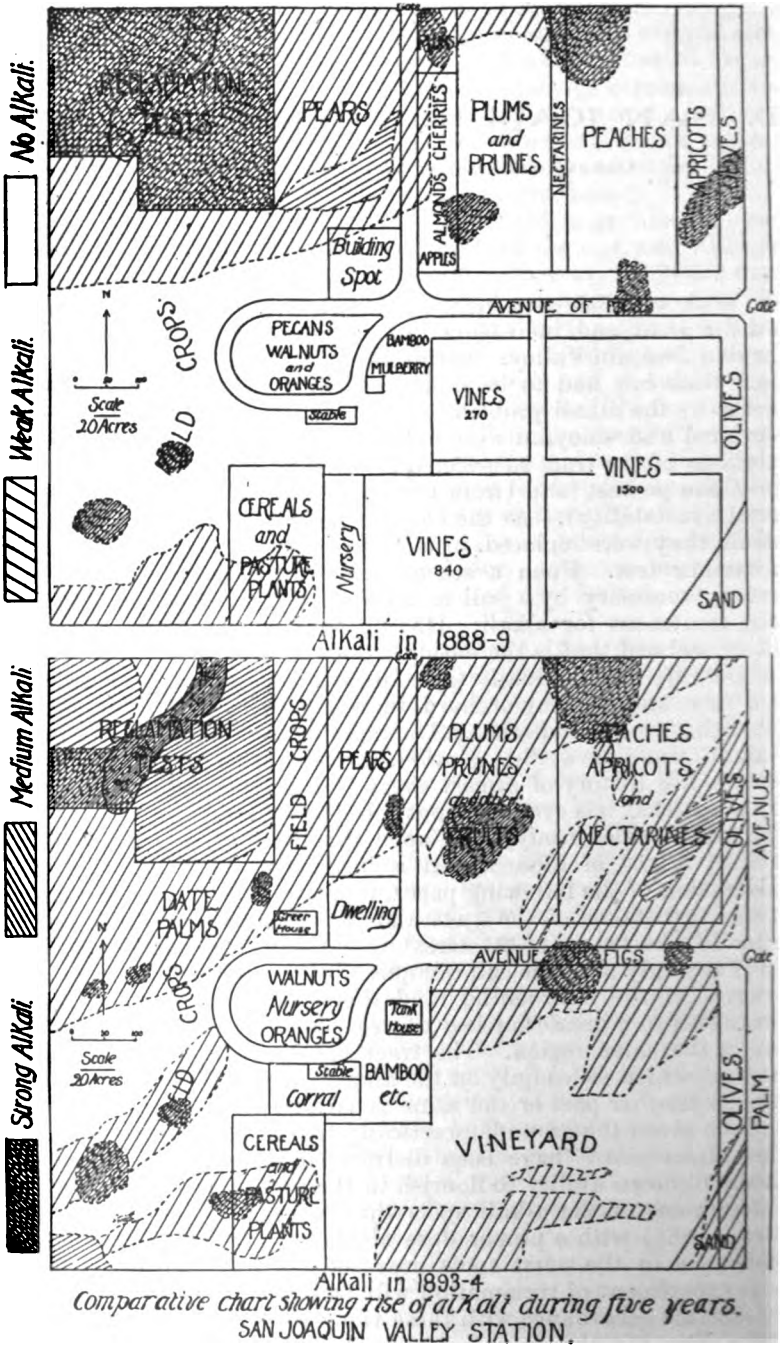

Comparative chart showing rise of alkali during five years.
SAN JOAQUIN VALLEY STATION.

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in the soil, and the problems connected with its treatment have therefore become more and more difficult. This corresponds closely to the principles laid down in the University Bulletin No. 83, and in similar publications of the Central Experiment Station, both in bulletins and in pamphlets. A map made in the summer of 1893, five years later than the previous chart, amply illustrates the nature and extent of this change. Light alkali, wherever not treated, has grown worse; alkali has appeared where in 1888 there was little or no sign of its presence. In the apple orchard, for instance, my predecessor, Mr. Klee, a very careful observer, stated in 1888–9: "In planting these, the alkaline spots were almost totally avoided, soil of this character being considered unfit for apples. The growth of the forty varieties planted has been very fair." But, as noted in the separate report on apples, a portion of the orchard is a failure from excessive alkali, and nearly all the trees have suffered. The only reasonable explanation is that there has been an increase in the amount of alkali at or near the surface of the soil. The lower map will repay careful study in connection with the preceding one. Taken together, they outline the problems of reclamation involved in the work of the Station.

Climate.—Besides the light rainfall of the district, the temperature report is unusual for the Station, in that the minimum is higher than since the Station was established. The following comparative table is compiled from the monthly reports of observations:

Tulare Temperature Report for the Fiscal Year 1892–93.

	Daily Mean	Mean Daily Maximum	Mean Daily Minimum	Mean Daily Range	Extreme Maximum (with Date).	Extreme Minimum (with Date).
1892—July	81.77	106.06	57.48	48.58	118....3	52....14
Aug.	82.61	106.90	58.32	47.58	118....1, 17, 18	52....9, 11
Sept.	75.23	98.20	52.26	45.94	112....8	48....18 to 24
Oct.	64.38	82.96	45.80	37.16	98....4	32....16
Nov.	57.83	78.20	37.46	40.74	90....4, 11	30....15, 17, 20
Dec.	49.90	61.16	38.64	22.52	78....25	24....16, 17
1893—Jan.	45.48	54.77	36.19	18.58	76....15	28....21, 25
Feb.	50.75	65.07	36.43	28.64	82....21	28....27
Mar.	54.58	67.48	41.67	25.81	98....28	32....1, 10, 12, 13, 14
Apr.	59.20	77.64	40.80	36.84	96....21	32....7, 8, 13
May	68.61	89.35	47.87	41.48	104....11	42....1, 25
June	74.93	97.33	52.53	44.80	110....4	46....12, 13, 14

Appearance of Station.—The general appearance of the Station has decidedly improved during 1894. Those orchard trees that have been well established bore heavily, and in most cases the fruit was of fine appearance and quality. The vineyard exhibited great gains. Corn, sorghum, and many other small cultures were excellent. The Station, despite its disadvantages, produced more than enough hay to supply the horses. The trees near the dwelling and some of the avenue figs have made a notable growth. A new tank-house and tank were built during the summer of 1893 and water piped to the dwelling. The buildings have also been repainted. Everything has been kept in a very

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creditable condition of neatness. The Patron, Mr. A. J. Pillsbury, has shown an intelligent interest in the Station, and in the problems presented there, and the number of visitors from the better class of farmers is greatly increasing.

THE ORCHARD.

The orchard of 1893 is much the same as that of 1892, except that its good and its evil are more strongly marked. All the planting done in the past winter was with especial reference to the alkali, and its persistent treatment with gypsum before and after planting.

The method adopted for this special gypsum treatment is worthy of notice. After the holes are dug (rather larger than usual in orchard planting on good soil) and the tree is ready to set, a thin layer of gypsum is put in the bottom of the hole. Gypsum is mixed with the earth in filling in around the roots to within three inches of the surface. Mr. Forrer, the foreman of the Station, then takes an old fruit can that is cut open on one side, places it about the trunk of the tree, fills with mingled earth and gypsum around the outside of the can, and finally fills the space inside with pure gypsum. This amply protects the collar of the tree, where the alkali does most injury. Five pounds of gypsum, costing from 2 to 4 cents, at present prices of gypsum, are sufficient for a tree. In aiding trees already planted to withstand the enemy, it is often found best to make a shallow basin about the collar and larger roots, and place several pounds of gypsum therein.

On some of the land planted to trees in the above manner last winter, three successive settings of trees on different stocks have been killed by alkali, which has proved too strong for peach, almond, plum, and pear roots. On the same plot, barley sowed for a test fails to germinate on account of the alkali. The present local treatment with gypsum is therefore especially important. Besides the use of gypsum near the tree, as outlined, the entire surface of the orchard and vineyard is to receive a top dressing before the spring rains are over, and the amount of this will be noted hereafter, this report carrying operations only to the end of December, 1893. This broadcast use of gypsum is essential to success, as the small amount used about the tree will soon be dissolved and wash into the surrounding soil. There are already many spots in the orchard where barley will now grow, and others, as stated, where no crops will survive. By a uniform use of gypsum, the general grade of the whole tract is being improved, and the worst spots can receive special treatment afterward.

Before leaving the general subject, it may be well to note further that in planting trees in soil that contains any dangerous quantity of alkali, those places where the bark on the roots or collar is broken are peculiarly sensitive, just as alkali would be more severe upon a human hand if the skin were broken. Protection with grafting wax, oiled cloth or oiled paper is useful in such cases. The ends of the larger roots, after trimming smooth, should be treated in the same manner. The new roots that start are often killed by alkali in solution in the water they take up. Sometimes a tree that has been four or five years in strong alkali soil has never been able to make any more roots than it had when first planted. But if temporary protection can keep a tree in health until the roots have gone deeper the chance of success is

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increased, as the proportion of alkali in each cubic foot of soil usually becomes less as we descend.

Apples.—A glance at the charts will show where the apples have been planted—in the southwest corner of the main orchard block. Forty varieties, as noted previously, were planted when the orchard was first established. Nine or ten of these perished, were replaced, and others added, so that now we have some fifty varieties represented. Those which blossomed appear in the following table, compiled by Mr. Julius Forrer, foreman of the Station:

Statistics of the Apple Orchard—1893.

Name.	In Bloom.	In Leaf.	Fruit, Etc.
Keswick Codlin	April 4	April 4	Fruit kept from July 27 to August 17th.
Missouri Pippin	April 10	April 10	12 apples; kept till Jan. 7th, 1894.
Mountain Beauty	April 4	April 4	No fruit set.
Red Astrachan	Mar. 25	Mar. 25	No fruit set.
Red Bietigheimer	April 4	April 6	No fruit set.
Red Winter Pearmain	April 9	April 10	10 apples; gath'd Oct.23; kept till Jan. 7th.
Violet	April 4	April 4	No fruit set.
Wealthy	April 4	April 4	Apples kept till Sept. 10th.
White Winter Pearmain	April 9	April 10	No fruit set.
Whitney's Crab	April 6	April 6	No fruit set.

The varieties of apple that were planted only in the winter of 1892–93 were Cook's Seedling, Ingram, Wytha, Lankford, Gravenstein, and Hyslop Crab.

Those varieties that have no bloom, by reason of the alkaline soil in which they barely keep alive, are Sonoma, Pewaukee, Hoover, and Marshall's Seedling. Some others, including Alexander, Yellow Bellflower, Stump, Arkansas Black, Jonathan, Bledsoe, Loy, and Shannon, gave no blossoms, but may do so another season. Charlottenthaler has succumbed to alkali during the past year. The time of leafage was noted in the case of all varieties not blooming, but it can be fairly doubted whether it was normal in any case where the amount of alkali was sufficient to influence the growth of the tree. The eleven varieties tabulated, all fairly normal, were in full leafage (average of the eleven) on the 4th and 5th of April; but the average date of leafage of twenty-four varieties that did not bloom was April 8th. A comparison of the dates of bloom at the other stations justifies the conclusion that the *alkaline soils tend to delay the blooming period;* quite contrary to the behavior of trees in too dry or stony soils, where they always blossom earlier in the season, and often at an earlier age than on more moist or heavier soils.

Returning to a consideration of the table, Red Astrachan blossomed the earliest of all, blooming March 25th; White Winter Pearmain, March 27th; the latest were Red Winter Pearmain, April 9th, and Missouri Pippin, April 10th. This is practically identical in point of beginning, with the season at Paso Robles, but at the latter station the blossoming season of the orchard, taken as a whole, appears to last ten days longer. The separate varieties, however, appear to occupy much the same relative position, if we disregard those varieties that grow in the stronger alkali soils, and this is evidence of the approximate correctness of the observations taken.

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Apricots.—Only a few varieties of the Royal type bore any fruit, and that was stolen. The varieties that blossomed are represented in the following table:

Statistics of the Apricot Orchard—1893.

Name.	In Bloom.	In Leaf.
Alberge de Montgamet	March 15	April 4
Beauge	March 18	April 8
Boulbon	March 26	April 6
Breda	March 20	April 6
De Coulorge	March 20	April 8
Hemskirk	March 20	April 4
Kaisha	March 25	April 8
Large Early	March 15	April 4
Large Early Montgamet	March 20	April 4
Long Red	March 20	April 6
Musch-Musch	April 4	April 10
Oullin's Early	March 20	April 6
Pringle	March 25	April 6
Red Masculine	March 11	April 8
Routier's Peach	March 15	April 4
Royal	March 15	March 24
Russian	April 4	March 10
St. Ambroise	March 11	March 4

The earliest-blooming variety is the Alberge de Montgamet; not until five days later, the Royal, Large Early, and Routier's Peach are in bloom. The small and much earlier-fruiting Pringle blossoms much later, on March 25th, with Kaisha. The hardy Russian and Musch-Musch do not blossom till April 4th, and this may be said to close the blossoming season of twenty-five days. The season of bloom appears somewhat longer than at Paso Robles Station, and it remains to be seen whether or not the fruiting season is also longer.

The apricots that failed to bloom in 1893 are the following: Moorpark, Peach, Sardinian, Smith's Triumph, Canino Grosso, and Viard. Trees newly planted were Gooley's Seedling and Flickinger. As a rule, the apricots have made better growth during 1893 than in 1892, owing to the liberal use of gypsum close to the trunks of the smaller and the newly planted trees.

Almonds.—Bidwell Mammoth, a giant hard-shell, is bearing somewhat. Ten of the leading varieties of almonds were planted here five years ago, and others have been added; but the effects of alkali are very evident, and more than half of the orchard has succumbed to the enemy. The remaining sorts are Bidwell's Mammoth, which bloomed February 26th; Harriott's Seedling, February 15th; and I X L, February 24th. The earliest to show leaves was Harriott's Seedling, February 24th, and all the others were in leaf by March 6th.

Nectarines.—The record continues to be fairly good, though there is room for great gain by the use of gypsum about the trees. Mr. Forrer reports upon ten varieties, all of which bore fruit. Hardwicke was in bloom March 15th, in leaf March 27th; Stanwick, Downton, Victoria, and Early Newington bloomed March 20th, and were in full leaf between April 4th and 6th. Early Violet, Boston, and Lord Napier bloomed March 25th and were in full leaf about with the rest. The fruit of all was of good quality and of fair size, and all were ripe during the same week—in the middle of August. Evidently the nectarine season is shorter in this district than in the coast regions. As the ten varieties

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listed cover nearly all in cultivation (the nectarine being a somewhat neglected fruit, not yet taken up by many specialists), the season could hardly be lengthened except by adding a variety like Hunt's Tawny, for very early, and Red Roman and Late Melting for last crop.

Peaches.—Half of the peach orchard is in excellent condition; the rest continues to be seriously affected by alkali. In tabulating the blossoming period, etc., it must be remembered that alkali affects all the trees in proportion to its strength. Strong alkali soil is colder, and blossoms and leaves often come out five or six days later on such soils, as is shown in cases where trees of the same variety are planted in different parts of the tract. The following table is compiled from notes taken by Mr. Forrer:

Observations on Peach Growth—1893.

Name.	In Bloom.	In Leaf.	Ripe.
Beer's Smock	March 25	April 6	Sept. 15
Belle Douay	March 24	April 8	August 6
Belle de la Croix	March 27	April 6	No fruit.
Bilyeu's Late	March 27	April 6	No fruit.
Bonanza	March 15	April 27	No fruit.
Brandywine	March 15	April 6	Sept. 10
Briggs' May	March 24	April 6	No fruit.
Canada Cling	March 15	March 27	Sept. 4
Chinese Cling	March 15	March 27	Sept. 6
Dr. Hogg	March 25	April 6	August 6
Early Alfred	March 25	April 4	No fruit.
Ford's Improved	March 15	March 27	No fruit.
George's Late	March 20	March 4	No fruit.
Golden Cling	March 20	April 6	No fruit.
Grosse Mignonne	March 25	April 4	No fruit.
Hale's Early	March 20	April 4	August 10
Henrietta	March 24	April 4	No fruit.
Jennie Worthen	March 24	April 8	No fruit.
La France	March 15	April 6	Sept. 4
Large Early York	March 27	April 6	Sept. 12
Lemon Cling	March 20	April 6	No fruit.
Lemon Cling (on alkali)	March 25	April 6	No fruit.
Lovell	March 15	March 27	Sept. 6
Mary's Choice	March 15	March 27	No fruit.
Mountain Rose	March 27	April 6	No fruit.
Newhall	March 18	March 27	No fruit.
Nichols' Orange	March 15	March 27	No fruit.
Noblesse	March 15	April 4	Sept. 10
Oldmixon Cling	March 15	March 27	October 1
Peen-to	Feb. 28	March 7	No fruit.
Picquett's Late	March 27	April 6	October 1
Prevost	March 25	April 4	August 25
Richmond	March 27	April 6	No fruit.
Runyon's Orange	March 15	April 4	No fruit.
Salway	March 15	March 27	October 13
Schumaker	March 15	March 27	No fruit.
Smock's Late Free	March 27	April 6	No fruit.
Stump the World	March 25	April 6	No fruit.
Susquehanna	March 20	April 4	Sept. 1
Ward's Late Free	March 20	April 6	No fruit.
Waterloo	March 20	April 4	No fruit.
Wheatland	March 20	April 4	Sept. 1
Wilkins' Cling	March 15	March 27	No fruit.
Wonderful	March 20	April 6	Sept. 21
Yellow St. John	March 15	March 25	No fruit.
Yellow Tuscany Cling	March 15	March 25	No fruit.

In all the above list the peaches are reported to have bloomed from the date first mentioned till the leaves came out. The earliest of all is, of course, the Chinese flat peach, Peen-to, or saucer, blooming February

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26th. No other variety showed flowers until March 15th, or seventeen days later; but no less than fifteen varieties out of the forty-eight tabulated burst into bloom on that day. The blossoming closed March 27th, with six varieties. Leaving out the Peen-to, the main blooming season of some sixty varieties at the Station is within the last two weeks of March, and the period of leafage extends to the second week of April.

According to Mr. P. J. Berckmans, of Augusta, Ga., the Peen-to peach blooms in Georgia in January, and it does the same in Alameda County in California. The tree itself is very hardy, but late frosts often destroy the blossoms. It bears heavily about one year in three at Niles. The lateness of bloom for this variety at Tulare City (February 26th) is remarkable, and on this account it may have a chance of fruiting. All the varieties of the interesting Peen-to type deserve more extended planting, on account of the early season at which the fruit ripens. In Florida Peen-to peaches are often ripe on the 1st of April. The newer sorts, as described by Mr. Berckmans, who grew the first "saucer peaches" in America, include the following: Angel, Arlington, Bidwell's Early, Bidwell's Late, June Beauty, Red Ceylon, and Waldo.

At Tulare City, as at Paso Robles, the peach season is shorter than in many mountain or foothill districts. When Hale's Early does not ripen till August 10th, and Salway October 13th, there must be nearly three weeks' compression in the possible range of varieties. Unless the Peen-to type succeeds, there can be no ripe peaches in this district earlier than the middle of July, even in very favorable years. Necessarily this fact reduces the number of essential varieties, both for home and market purposes. The weeding-out process is of vital importance here.

Pears.—As explained in last year's report, the pear orchard certainly shows the most striking exhibition of the effects of strong alkali. It is a common misconception that pears will succeed on the worst of alkali soils, just as one hears that beets will reclaim any such soil by taking up the injurious salts. Emphasis must again be put upon the fact that what we call "strong alkali" soils at the Tulare Station, are soils in which the percentage of alkaline salts is something like 1.0 per cent or over—soils on which no crop will grow, and in which no seeds can germinate. On a soil less strong in alkali, beets can indeed be grown after a fashion, and trees of tough bark and strong texture, such as the pear, may indeed grow with difficulty. As the alkali decreases, better specimen trees are produced, until the normal orchard is reached, when it will be found that ordinary hay and grain crops do well there, though not all the fruits. A small amount of alkali does no injury to the pear: all that the tree can assimilate goes to growth and fruit, but beyond that we should theoretically expect checked growth, and disease. It is possible that the pear orchard may be planted on land too strong in alkali for apples, peaches, almonds, and apricots, but it is not possible for it to thrive on land where grain crops do not prosper.

The following table contains all the varieties that fruited at the Station in 1893:

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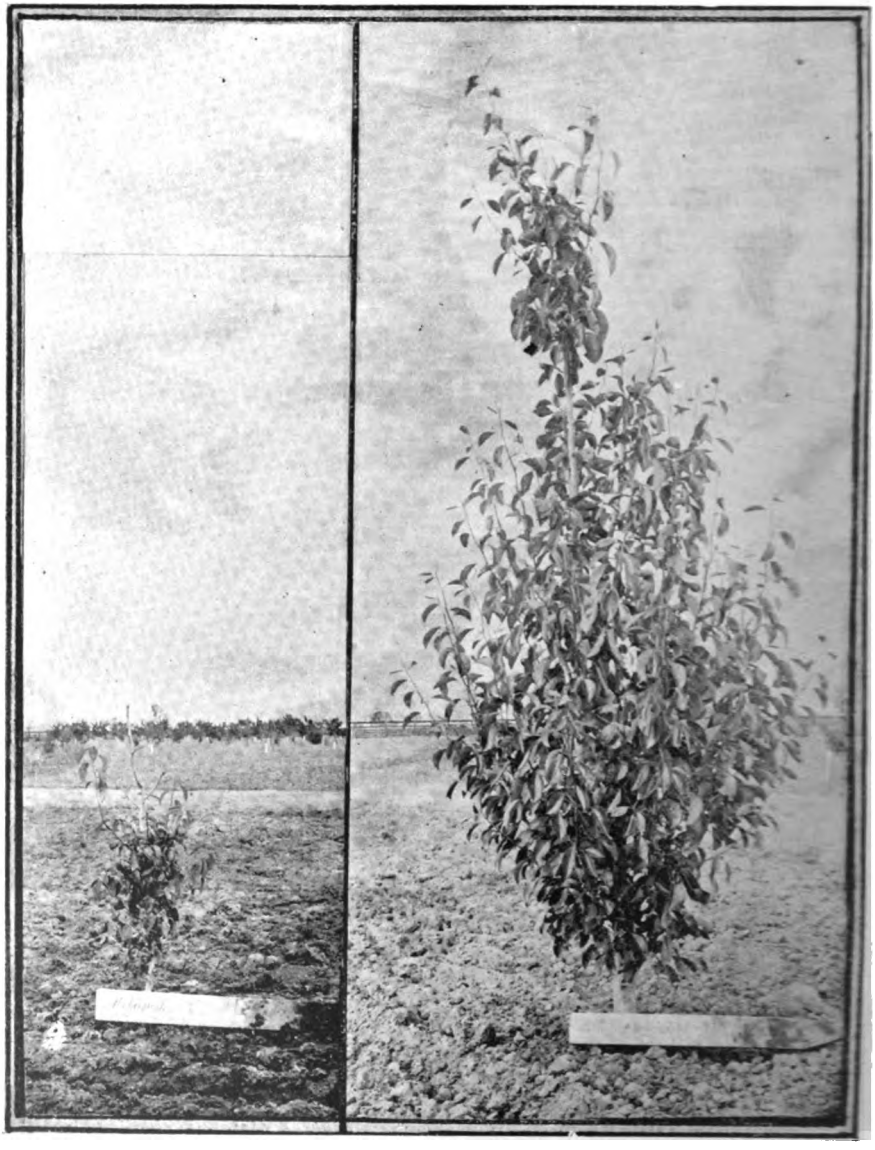

URBANISTE PEAR on Alkali. BEURRE D'AMALIS, on Weak Alkali.

Pears 5 years old on Alkali Soil.

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Statistics of the Pear Orchard—1893.

Variety.	In Bloom.	In Leaf.	Crop.
Bartlett	Mar. 25	April 4	Sept. 20; kept till Oct. 1; av. weight, 10 oz.
Beurré Clairgeau	Mar. 27	April 4	Sept. 20; kept till Dec. 25; av. w'ght, 1 lb. 7 oz.
Beurré d'Amanlis	Mar. 27	April 4	Sept. 12; kept till Oct. 10; av. weight, 14 oz.
Beurré Gris d'Hiver Nouveau	April 4	April 4	Nov. 7; kept till Jan. 7; av. weight, 1 lb.
Dearborn Seedling	Mar. 27	April 5	Aug. 15; kept till Aug. 25.
Duchess d'Angoulême	April 4	April 4	Sept. 25; av. weight, 1 lb. 7 oz.
Easter Beurré	Mar. 27	April 5	Nov. 7; kept till Jan. 7; av. weight, 1 lb. 2 oz.
Le Conte	Mar. 27	Mar. 27	Sept. 24; kept till Oct. 10; av. weight, 9 oz.
Louise Bonne de Jersey	April 4	April 1	Oct. 5; small, poor, not kept.
Mount Vernon	Mar. 27	April 3	Nov. 7; kept till Dec. 27; av. weight, 1 lb.
P. Barry	Mar. 27	April 4	Sept. 24; kept till Dec. 20; av. weight, 13 oz.
Swan's Orange	April 4	April 4	Sept. 24; kept till Oct. 1; av. weight, 9 oz.
White Doyenne	April 4	April 4	Sept. 20; kept till Oct. 1; av. weight, 10 oz.

Some items in this table go far to illustrate the immense diversity of climate in California. Beurré Clairgeau keeping till December 25th without extra precaution, is certainly a surprise; so is Beurré Gris in January with Easter Beurré; in most places it is decidedly an autumn pear. White Doyenne and Dearborn's Seedling ripen about as one would expect, but Mount Vernon keeps five or six weeks longer than usual with that variety, and the October Bartlett completes the suggestion that this district is admirably adapted to the very late pears, of which several new varieties not yet in the nurseries have been originated during the last few years.

The pear orchard now contains sixty-five varieties. During the winter of 1893, a row of Le Conte pears was planted on the east side of the avenue, between the pear orchard and the main orchard. This row extends through several grades of alkali soil, and will give a desired test of comparative growths of the same variety. Eventually, such trees as can be made to flourish under these conditions, will be top-worked to new varieties.

Plums and Prunes.—In 1888–89, a collection of seventy-five varieties of plums and prunes was planted here; nearly all were on Myrobalan stock, but these have all died from the alkali. The Myrobalan stock certainly stands light alkali soils quite well. The Mariana tree noted last year continues to thrive better than the Myrobalan, and will be tested as a stock in such locations. Unfortunately, trees on Mariana roots, ordered for last winter's planting, failed to come to hand, and it will take another year to obtain them.

Eighty-two varieties are now represented in the orchard, some planted in the winter of 1892, others of two, three, four, and five years of age. The varieties bearing last season number thirty-one, and are retabulated below:

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Statistics of the Plum Orchard—1893.

Name.	In Bloom.	In Leaf.	Crop Ripened.
Bavay's Green Gage	March 27	April 10	Oct. 10
Belle de Septembre	April 4	April 14	Oct. 13
Botan	March 15	April 6	Aug. 18
Bryanstone Gage	March 25	April 4	Sept. 10
Cherry	Feb. 25	March 15	Aug. 18
Columbia	March 25	April 4	Sept. 18
Czar	March 11	April 4	Aug. 6
Damson	April 1	April 10	Sept. 25
Duane's Purple	March 27	April 6	Aug. 6
Early Golden	March 27	April 7	Aug. 25
German	March 25	April 4	Oct. 6
Guthrie's Late	March 25	April 4	Sept. 6
Imperial Gage	April 4	April 10	Sept. 15
Judson	April 4	April 10	Oct. 4
McLaughlin	March 25	April 4	Sept. 6
Perdrignon Blanc	April 4	April 14	Sept. 30
Petite d'Agen	March 25	April 4	Oct. 16
Pond's Seedling (Grosse Prune d'Agen)	April 4	April 10	Sept. 25
Prince Englebert	April 3	April 10	Sept. 15
Prince of Wales	March 25	April 4	Sept. 6
Robe de Sergent	April 4	April 10	Sept. 28
Shropshire Damson	April 4	April 10	Sept. 19
Silver Prune	April 4	April 6	Sept. 28
St. Lawrence	March 27	April 6	Oct. 10
Victoria	April 4	April 10	Oct. 1
Wangenheim	April 2	April 8	Sept. 15
Yellow Gage	March 25	April 4	Aug. 20
Yellow Magnum Bonum	April 3	April 10	Sept. 10

CEREALS AND SMALL CULTURES.

Only a small collection of selected cereals was grown in the spring of 1893, owing to the dryness of the season and the fact that so many varieties had been grown in previous years. The alkali reclamation work occupied much of the time of the Station force. The following table shows the yield of drilled wheats, on land that was partly alkali. All were sown December 9th and 10th, 1892.

Wheat—Season of 1893.

Name.	Length of Drills.	Number of Drills.	Yield.
Archer's Prolific	100 feet	4	25 lbs.
California Spring	100 feet	6	44 lbs.
Clawson	100 feet	2	14 lbs.
Defiance	100 feet	3	16 lbs.
Greek Atlanti	30 feet	5	8 lbs.
Indian Three-months	100 feet	4	32 lbs.
Michigan Mixed	100 feet	2	17 lbs.
Missoyen	30 feet	4	7 lbs.
Palestine	30 feet	3	6 lbs.
Rust-proof, Indian	100 feet	3	16 lbs.
Volo	20 feet	3	5 lbs.
Whittington	100 feet	4	24 lbs.
Yellow Noe	100 feet	3	18 lbs.

Himalaya Barley.—On December 11th, 1½ pounds of Himalaya barley, Experiment Station selected seed, was sown broadcast upon 7,600 square feet of the average soil of the Station tract. It received no extra care nor any irrigation, and the total rainfall of the season was only 7.44

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inches, but the crop yield was 250 pounds of clear seed. Deep plowing and thin seeding were the secrets of this result. This is a very early barley and a very heavy yielder. It would be profitable for hog-raisers in the San Joaquin Valley; probably a better barley for this purpose than any of the lighter-colored varieties.

Nepaul Barley.—The best barley so far tested for hay is Nepaul, a beautiful beardless barley that seems to suit the district in every particular. The head is large and heavy, the straw is very soft and sweet, so that horses will eat the entire stem. There is much less waste than with ordinary barleys, or with wheat hays, which waste nearly all the straw. The Station bought no hay in 1893, and has surplus hay enough to carry us over 1894, should the hay crop prove a failure. The success of the Nepaul barley at the Station has been so marked that there has been an increasing demand for the seed, and several persons who obtained a small stock from the University of California are now growing and selling seed barley at 3 cents a pound. Two and three tons to the acre has been a fair crop at the Station with ordinary field cultivation.

Sorghum.—This crop has been made a specialty at the San Joaquin Valley Station, chiefly through the persistent efforts of the foreman, Mr. Julius Forrer, who has distributed a great deal of seed of the best sorts in our collection, so fully described in earlier reports. *Sorghum vulgare* proves to be an improvement on the ordinary Egyptian corn, ripening three weeks earlier and yielding more to the acre. Sometimes there are twenty or more heads to one plant. This sorghum is also of a more dwarfed growth than the Egyptian, and appears to thrive on drier soil. Horses and cattle will eat the stalks quite as well as they do the common sorghums.

FIGS AT TULARE STATION.

By Julius Forrer, Foreman.

The fig trees at the Station have done very well in many cases, and the collection continues to attract notice from all summer visitors. While the general observations made in previous seasons continue to hold good, there are many details respecting varieties that require additional notes.

Abondance Précoce.—Only a medium grower, but with short, stocky branches, and quite hardy. The small fruit is abundant. The figs are light-brown, streaked with green, and the rich flesh ranges in color from white to dark pink.

Agen.—A slow-growing variety, one of the hardiest in the list. Fruit small, but excellent. It is a fair bearer, though not as good as some.

Angelique.—Slow grower here, and touched by frosts; has not yet fruited.

Bourjassottes (Black, Green, White, and Gray).—All four varieties, though thrifty, are somewhat tender. The white does not mature its fruit, though the tree is of good size, and should bear. The black is still small. The gray suffers from frost. The green is the hardiest of the four, and bears well; its fruit, medium in size, grayish in color, and red-fleshed, is of excellent quality for its type.

Breba.—A vigorous grower, and hardy. An immense number of figs are set and some fall off. No fruit has ever matured.

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Brown Turkey.—A slow grower, and hardy. The light brown fruit has pink flesh and is medium in size; the tree is a moderate bearer.

Brunswick.—A good grower, but more tender than the majority of figs. The fruit has a peculiar shade of brownish-yellow and its flesh is pink-colored and sweet. The fig much resembles the Smyrna of California, and the growth of the trees is similar, but the leaves differ in shape.

Cernica.—This variety stands the frost well, but is not yet bearing.

Col di Signora Bianca.—This strong-growing variety is as hardy as any except Dorée Narbus, and it bears very heavily. The fruit is medium sized and of good quality.

Dalmatian.—This fig is a slow grower, and quite hardy. The fruit in color, size, and quality greatly resembles the Smyrna of California, and the Brunswick, except that it is more flattened and one-sided in shape. The ordinary grower does not need more than one of the three varieties.

Dattato (Black and White).—The black is a very small tree, but appears quite hardy. The white is more susceptible to frost.

De Constantine.—This vigorous grower stands the frost well, and bears heavily. The medium-sized, purple fruit is striped with green toward the stem, and its dark-red flesh is of fine texture.

Dorée Narbus.—This is a very strong grower, with short-jointed, sturdy branches of peculiar appearance. It easily withstands frost at 20°, and has withstood 17°. The small fruits, of very light yellow hue, are delicious in flavor. The white flesh, cream-colored at the core, is very juicy and sweet. Its bearing qualities are excellent, and this tree can be recommended for the home orchard in cold, frosty, or windy situations.

Drap d'Or.—A firm grower, but the tree is quite tender, suffering materially at 20°. The fruit is choice in quality, flesh white with pink center, and the skin of a light brown color.

Du Roi.—A very attractive and valuable acquisition. A hardy, good grower, and heavy bearer, covering an extended season. The medium-sized figs are white in color, and the flesh is white, deepening to a cream-tinted core. In quality, the fig is unsurpassed, and many think unequaled by any of the other varieties grown here. Du Roi and Hirtu Du Japon maintain themselves as two of the best table figs, and each successive season has only confirmed their value. In hardiness, Du Roi affords a refreshing contrast to the White Adriatic.

Early Violet.—The tree has suffered severely from frost and is not yet bearing. Like several other varieties, it is too tender for the locality.

Gros Gris Bifère.—This has proved a most tender tree, even light frosts affecting it. It starts up in spring and makes rapid growth. On poorer soil it might prove hardier, but it is evidently more suitable for the frostless districts. No fruit as yet.

Grossale.—This and the *California Black* are both small trees not yet in bearing, but have stood the frosts well.

Hirtu Du Japon.—This notable variety, new in California, deserves high praise and general introduction. It is of slow, compact, hardy growth. Indeed, it might almost be called a dwarf fig, making little wood. Its immense load of fruit is astonishing, and it is nearer to a perpetual bearer than any other fig at the Station. The round, purple figs are of medium size. The flesh is white, but with brown specks of imperfect seeds, and cream-tinted heart. The quality is unsurpassed

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among all the figs. This is one of the best varieties for the garden, yielding twice as much to a given surface as any of the older varieties, and better for the table than any except the Du Roi.

Ischias (White, Brown, and Black).—The White Ischia, a very old and famous variety, is a slow grower here, and stands frost well. The fine-textured, delicate fruit ranges in size from small to medium, and is one of the sweetest and best on the list. Brown Ischia, in growth and hardiness, resembles the white, and is a heavy bearer. The black is more tender, bears well, and yields an excellent and very sweet fig.

Ladora.—Here is another variety of doubtful hardiness here, though it will fruit. The figs are slender in shape, brown in color, and of very fair quality; size medium.

Marseilles (Black and White).—The Black Marseilles tree is thrifty, but quite tender. The small, jet-black fruits are very sweet, and of high quality here. The stems are twice as long as the fruits themselves. A better family fig in the foothill districts than the more common White Marseilles, as it seems to be a better bearer, and preferable as an eating fig, though the white is of larger size here. There is little difference in growth of the trees, or in hardiness.

Monaca Bianca.—This proves to be a thrifty grower here; tree as tender as the Drap d'Or. A small, yellowish fruit, white fleshed, with pink center. The quality is fair to good, and the bearing capacity is large.

Negro Largo.—One of the strong growers, but decidedly susceptible to frosts of 20° and 21°. The fruit ranges from large to very large—a long black fig, sweet, and not coarse in grain. It is an excellent bearer here, and a very showy variety for exhibition purposes.

Osborn's Prolific is certainly well named, as it proves one of the best bearers. In growth of tree and hardiness it resembles the White Ischia. The small, rich, and sweet figs, brown in color, are of high quality.

Pasteliere.—A particularly thrifty grower, with short, strong joints. It is a hardy, early bearer, and productive; the fruit is large, long in shape, and with red flesh; the quality is from fair to very good.

Petrovaca.—A most vigorous grower, and very hardy, but, like Breba and the Bulletin Smyrna, the fruit does not stay on the tree.

Rargigna.—This is a strong-growing, hardy, moderate bearer. The medium-sized fruit of light cream, almost white color, has a perfectly white flesh. This is the most juicy of all the varieties grown at the Station.

Rocardi.—This is here a good grower, fully as tender as Drap d'Or. The fruit is small, greenish in color, with delicate purple stripes over the larger end; the flesh red and rather coarse. Quality is distinctly second-rate here; an excellent bearer.

Ronde Noire.—A strong grower, sensitive to frosts, but still bears in ordinary seasons. The skin is purple, the flesh dark-red to the core, and of very rich flavor. It is of the best of the dark-fleshed type, to which the Black California belongs.

Ronde Violette Hâtive.—Is here a very vigorous grower, and easily withstands 20° Fahr. The fruit ripens in July, is one of our earliest varieties, and in size ranks as medium to large. The color at the stem end is green, shading to brown at the apex. The first crop is also the main one; hardly any second crop. The fig is very solid, and yet juicy. It is one of the best for preserves and sweet pickles.

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Royal Vineyard.—This fig, though a slow grower, is much subject to frost. The brownish fruits of medium size are of fair though not high quality.

San Pedro.—This is well recommended as a table fig elsewhere, but, like Gros Gris Bifère, freezes down every year at the Station.

Smyrna (true; Bulletin).—The tree is a vigorous grower and more hardy than any other large fig. Like the Breba, an immense number of figs have set, but all have fallen off when small. Caprification with pollen sent from a bearing tree of Capri, or wild fig, in the orchard of James Shinn, Niles, was attempted. The season was late here, before the pollen was ripe at Niles, and hence it did not take very well, but several figs that were pollinated matured. They were rather large, round in shape, juicy and delicious. The flesh was perfectly white and of unusually fine texture. A remarkable fig in all respects, and worth every effort to bring into full bearing.

Smyrna (of California).—A slow grower here, perhaps partly due to location; stands frost well. The fruit is greenish in color, tinted to brown; the flesh white, with pink center. It is not a heavy bearer.

Trojano.—A small tree, and was frosted last winter.

White Adriatic.—Probably the best known fig now in cultivation in California, and very useful for purposes of comparison. Ordinarily, and particularly on the heavy, alkaline soils here, the growth of this variety is very sturdy and rapid. But the tree suffers as much from frost as any other variety known; it seems sometimes as if it suffered even more than others, and loses large branches. Notwithstanding the great reputation the fruit bears, it seems to me evident that here, at least, it is one of the poorest that we grow. The coarse-textured red flesh is not attractive, compared with other varieties, and the thick, tough skin often bursts at the apex, so that the flesh sours in this climate. The juice is often seen running out on the ground, and swarms of wasps and bees haunt the trees. No one in Tulare will plant White Adriatic any longer.

White Brogiotto.—A good grower and of medium hardiness, but the tree has not yet borne fruit.

White Genoese.—Strong grower, but very tender; no fruit.

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E. SOUTHERN CALIFORNIA STATION.

In the Chino Valley, between Pomona and Chino.

By CHARLES H. SHINN.

The Southern California Experiment Station is becoming more and more attractive to the visitor. It lies in the heart of the great Chino Valley, close to the boundary line between San Bernardino and Los Angeles Counties. Chino, Ontario, and Pomona are already closely connected by steam railroads, and several electric lines are projected in the valley. Farmers from every part of Southern California can easily reach the Station grounds at any time of the year, and are always welcome there.

General View.—The Station was established in the autumn of 1890, and the planting of vines and trees began in the spring of 1891. Additions were made to the orchard and vineyard in 1892 and 1893. The 30-acre tract consists of a parallelogram of 22 acres extending east and west, with 8 acres attached in a smaller square on the south. This gives a better variety of soil than if the whole tract had been made square. The buildings are near the southeast corner, and are well arranged, with ample walks and driveways, which are now being covered with asphaltum given to the Station by Mr. Richard Gird, from his large asphaltum mine in the hills near Chino. A street lies on the east side of the tract, and another street on the north, both open and being built upon.

Nearly all the large parallelogram above referred to is devoted to orchard and vineyard, planted and in good condition. The chief exception is in the arboretum and nursery blocks, which occupy a comparatively narrow strip extending west from the house, along the northern line of the tract. The arboretum is a block 210 feet wide and about 400 feet long, including the circular reservoir of 60 feet in diameter. This is being planted to specimen trees grouped so as to leave vistas across the reservoir and will not only add to the beauty of the place, but must also serve as additional shelter to more tender plants in the garden. West of the arboretum, the small fruits, nursery, vegetable garden, grain plots, and small cultures extend to the northwest corner of the tract.

The small square south of the larger parallelogram, heretofore used for hay growing, will be needed for orchard before long, and the olives, cherries, plums, and apples are already extending south over this part of the Station tract. In the main orchard, thirty-eight rows of trees are planted, and all of them except a few on the Station side where the stable and roadway occupy some space in the edge of the orchard, consist of twenty-six trees. When extended across the hay field, there will be room in all the sub-orchards for nearly 1,500 trees, and the planting has been so wide apart that small fruits can be grown between many of the rows. Restricted to two trees of leading varieties and one tree of

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varieties of less importance, a thousand varieties can easily be represented here.

The earlier difficulties of establishing the Station have been met and overcome. A change of foremanship made in the autumn of 1893 was the most important step taken since the last report. The new foreman, Mr. J. W. Mills, has been both active and efficient in his work, and the Station has greatly improved under his management. Public interest in the work of the Station is greater than ever, and we are indebted to many citizens of Pomona, Chino, Ontario, Riverside, Redlands, and Los Angeles for visits, and in many cases for rare seeds and plants. There is no place in California where earnest and capable horticultural work is more readily appreciated than in this district. Intensive horticulture is everywhere developing along broader lines; olive, orange, and lemon groves extend in a broad belt along the base of the mountains, while the culture of sugar-beet and deciduous fruits occupies the heart of the valley. The more notable home colonies of Southern California are within reach. In no other region where an outlying Station has been established is there better material, or more interest in the work to be done. From its foundation every newspaper in the three towns of the valley, and many outside, has devoted more than ordinary attention to the Station.

Improvements.—During 1892–93 an addition to the barn was made, doubling the size of floor space and affording room for wagon and tool shed, additional hay, etc., and much improving the general appearance of the place. More water pipe was laid, hot-bed frames built, and repairs made as needed in the house. The water supply from the reservoir for orchard and nursery irrigation proved sufficient, but it will be necessary to build a tank-house and use a small windmill to furnish the house supply. The pressure obtained from the main pipe is barely sufficient to fill the 100,000-gallon reservoir used for irrigation. A hose cannot be used in the garden without greater pressure, only to be obtained by a tank and a windmill. A system of distributing water is now being arranged by which the exact amount used can be determined.

THE ORCHARD.

Every visitor is pleased with the fine growth of the fruit trees. Since the last report, many additions have been made. There are but few seedlings and comparatively few changes to be made in the sub-orchards.

Sparrows and other small birds last winter ate many buds of peach, almond, apricot, cherry, and nectarine. Mr. Mills shot and poisoned some, and sprayed his trees with various compounds that it was thought might stop their depredations, but a large part of the fruit crop was lost. The orchard lies on the outskirts of the settlement and suffers more than others in this region, but there is a difference in the seasons, and in some years birds do little or no damage. Last year they were especially troublesome in many districts.

Olives.—Olive-culture is rapidly becoming one of the most important industries of the Chino Valley. The headquarters of the business is in and near the town of Pomona, and some of the most intelligent olive-growers of California belong in this district. With great liberality these gentlemen have sent to the Station trees of every new variety of

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olive obtained by them, and our collection promises to become one of the best in the United States, if not, indeed, already the largest of its kind. It includes sixty-six distinct varieties, and there are two or three good specimens of each variety. Besides this, we have about one hundred seedlings of Rubra that have not yet fruited. The complete list of varieties is given in the appendix to this report, tabulated as a supplementary list of the fruit trees at the various stations.

The olive sub-orchard begins along the southeast side of the tract, and occupies seven rows. There are a few vacancies to be filled, and the orchard can be extended south, into the block that is now used for growing hay, so that there is room for many more varieties. The seedlings are chiefly planted in the main streets. Many of the trees are three years old, and the best grower in this class has been Nigerina. Huff's Spanish, Nevadillo Blanco, Præcox, and Pendulina are also excellent growers.

Lemons.—The lemon sub-orchard is really only a part of the citrus-fruit orchard, of five long rows, immediately west of the olive orchard. The representation of varieties is small as yet, though some promising new sorts have been obtained from prominent lemon-growers of Ontario, a notable lemon district. Stock had also been planted to use for top-working new varieties of oranges and lemons in the budding season. Lisbon, Eureka, and Villafranca are the largest three-year-old trees in the orchard.

Oranges.—The California and the older Florida varieties are fairly well represented in the Station. New sorts are now being obtained. A large number of choice seedling stocks have been set in orchard form ready to top-work, so as to hasten the bearing of any new variety. Space has been reserved so that the citrus fruits can be given a larger representation every year. Two trees of each variety have been planted, except of Washington Navels, of which twelve were set to facilitate future experiments, and six of them will be reserved. All the orange trees have grown well; the Pineapples and Magnum Bonums are as large as any.

Almonds.—West of the citrus fruits is the one almond row, which affords room, however, when extended across the tract, for all the desirable varieties known to horticulturists. Almonds have been a genuine surprise to the district, so well do they grow, and such bearers did the three-year-old trees prove, last season. The blossoms have not yet suffered from frost, and if the birds leave the buds alone, an almond crop seems safe in this region. Even the Languedoc bore well in 1893–94. The strongest-growing tree is Drake's Seedling, with Golden State and Marie Dupreys a good second, and Nonpareil and Sultana about equal. The almonds attracted much attention, and were visited by many orchardists, some of whom decided to plant commercial almond orchards upon the strength of the showing made. Very little almond planting had been done before in the Chino Valley.

Cherries.—Still farther west comes the cherry row. In this district the cherry is probably destined to be a fruit of secondary value, though some of the southern Russia sorts may stand the heat better than the common European types. The trees grow but poorly and "gum" badly. They were, of course, headed as low as possible, and have been well cared for. Elton, Rockport Bigarreau, and Willamette are probably the

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best trees in the row. The soil is light for cherries, and much better places for the fruit can be found in the region.

Peaches and Nectarines.—Five rows follow west of the cherry row, and these are devoted to peaches and nectarines, which most resemble each other in general character of growth. There is a good collection of both fruits, embracing some of the standard varieties and many of more recent introduction. The trees have grown evenly, and twenty or thirty might be named as of equal merit in point of size and shape. This sub-orchard will be enlarged considerably, as the district is well adapted to peaches and nectarines. The finest nectarines in the sub-orchard are Pitmaston's Orange and River's Orange.

Apricots.—West of the peach orchard are the apricots, occupying most of rows 19 and 20. The finest tree in the tract is the Blenheim. As a rule the growth of the trees is very satisfactory. It will be advisable to remove a few plums from row 20, so as to devote that row entirely to new apricots, of which many sorts are being propagated at the Central Station.

Plums and Prunes.—Six rows and part of another are occupied by this sub-orchard. It is in excellent shape and makes a very good collection. Most of the trees have been two and three years planted, though there are a few yearlings. Two seedlings and the Marianne plums are the largest in the orchard, but the average, as represented by Bulgarian prune, have made satisfactory growth. As with the other sub-orchards, some extension is practicable whenever necessary.

Pears.—In point of completeness, the pear collection, occupying five rows, leaves little to be desired, but the light soil of the main station tract is not well suited to this tree, and they have made the poorest growth of any trees in the entire orchard. From the present prospects, it will be wise to graft over duplicates and keep but one tree of a variety in this sub-orchard. We will be able to test one hundred and twenty varieties in this way without extending the orchard; meanwhile, we can start a pear orchard on the heavier soil of the ten-acre tract, which is much better adapted to this tree. There is no doubt of fair success with the pear on the main tract, but the fruit will be probably of only medium size, and the growth of the trees will be slow.

Apples.—The apple has been comparatively neglected in the Station, few varieties having been planted up to the present time. Row 35, in the main orchard east of the pears, is devoted to "apples and crab-apples," and a number of trees have been set in the hay field south of the orchard. The more recent plantings are mostly Russian varieties. The representation of varieties will be very materially increased in a few years, as something like a hundred new and rare sorts of apples are being propagated at the Central Station. We are selecting the finer seedlings from the Southern States, the Crimean provinces, and southern France, aiming to give this district choicer table and market apples. While the trees are of rather slow growth, they seem to thrive better than the pears, and the apple sub-orchard justifies further extension.

Figs.—The last three rows of the main orchard are devoted to figs, a fine collection, now almost complete, capable of receiving twenty-five new varieties, but already, as with the olives, a very choice and extensive plantation. Agen seems to be the best grower. Many of the trees are so young that as yet they offer few noteworthy characteristics. The trees suffer little from frost here, and it is evidently a good fig

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district. With the number of varieties here planted some valuable observations can be made as soon as they come into bearing, respecting the cause of "souring" on the trees, which evil has often ruined large crops of certain varieties in Southern California.

Grapes.—West of the fig sub-orchard is the main vineyard, where a large number of wine and table grapes are planted on very suitable soil, and have made very fine growth without irrigation. Some varieties bore a small crop in the season of 1893, and the coming season will probably enable us to make shipments to the Central Station to correct the nomenclature wherever faulty, and graft over the surplus stock. As with the olive, citrus fruits, almond, peach, apricot, and fig, the district is well suited to many grapes. More complete details will be found from time to time in special viticultural reports.

Walnuts and Chestnuts.—A very complete collection of grafted and seedling walnuts and some fine varieties of chestnut and of filbert were planted at the Station. It is perhaps too soon to say much about them, except that they seem to need considerable water until established. Walnuts have done well in the district and will doubtless thrive here.

Fruit in 1893.—The orchard was so young that no fruit at all was expected last season. Nevertheless the almonds yielded as follows: Sultana, three quarts; Ne Plus Ultra, Paper-shell, I X L, Flat-fruited, one quart each. There was one tree of each of the above kinds that bore fruit. The oranges that bore were of the Ruby, Homosassa, Tangerine, and Pineapple varieties, and the trees yielded from four to twelve fruits apiece.

CEREALS AND SMALL CULTURES.

Sorghum.—Fair growth, without irrigation; crop not used for fodder. Only small lots were planted in sandy soil, west of the vineyard. Whiting, New Orange, and Early Amber were among the best.

Perennial Cotton.—The plants survive, though killed back nearly to the roots by the light frosts. It is evidently a very tender plant from the *tierra caliente* region, and unlikely to succeed in any part of California. The chief trouble is in the late blooming. If the plants could be forced into earlier bloom they might possibly ripen up sufficiently to stand the winter better. In 1892 they bloomed in December; in 1894, in November.

This plant is known in its native region as the Catacaos cotton, and grows in great perfection along the banks of the Pima River in Peru. It reaches a height of 12 feet, and under favorable circumstances yields 350 pounds of clean cotton per acre, in two crops, January and August. This cotton is worth from three to seven cents a pound more than ordinary cottons. Its best soil is said to be deep and naturally moist loam. Eight years is the usual period of a plant's productive life. It is unlikely that more than one crop annually could be obtained in California, unless along the Colorado River.

Sugar Cane.—A poor start was made in 1892, when four out of five varieties sent from Louisiana failed to grow. The one remaining variety, the striped, did not receive enough water and only gave us a little stock for future planting.

Cereals.—A large collection of grains was grown in small test plots in 1893, but too late for the season or the district, and receiving little culti-

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vation, made such poor growth that orders were given to cut all but the ten or twelve best plots, for hay. The former foreman failed to keep any record of the cereals or of the grasses and clovers, so the report is necessarily defective. With early sowing and thorough cultivation, a fine collection of cereals could have been obtained for exhibition purposes, as well as for the comparative tests to ascertain the best varieties for the region, but this must now be left for another season.

THE MOIST-LAND TRACT.

In the autumn of 1892, arrangements were made to break the sod on the moist-land ten acres, two miles west from the main Station grounds. Some work had been done here at intervals, but nothing of any consequence. A contract was let to have the whole ten acres plowed twice and harrowed twice, using a six-horse team. Grass seed, sorghum, and corn were planted on four acres, and corn, squashes, and beets on the remainder. The soil proved very weedy, crop after crop of sunflowers springing up, and the ground remaining wet late in the spring and running together into a fine sod of grass and lowland growth. Wire-worms in the sod destroyed the grass seed and alfalfa sown, but the corn, squashes, etc., made a fine crop. There was not nearly enough cultivation of this tract through the summer of 1893, and the new foreman, Mr. Mills, has had to do the work over again, in a large measure, but is now master of the situation.

Value of this Land.—No other Station has so useful and attractive an adjunct as this ten-acre tract. Without drainage it is unfit for many species of trees, but in the course of time a general system will be adopted for the lowlands of the valley, and this tract will become of especial importance. Even in its present condition, it ought from this time forward to furnish all the hay and fodder that the Station requires, besides growing complete tests of many grasses, clovers, and forage plants, beets, melons, squashes, and a large range of moist-land crops. Some tree-planting on this tract is planned for next winter. In the end, at least half of it can be devoted to trees and vines. It is not necessary to fence it, as cattle are now shut out from this portion of the Chino ranch on account of the sugar-beet crops.

Grass-Sowings, 1893, 1894.—The following grasses were sown by Mr. Mills in the present season, 1893–94: Hungarian Brome Grass (*Panicum Germanicum*), Mesquite, or Velvet Grass (*Holcus lanatus*), Red-Top (*Agrostis vulgaris*), Perennial Rye Grass (*Lolium perenne*), Timothy (*Phleum pratense*), Tall Oat Grass (*Avena elatior*).

SWEET POTATOES.

Literature of the Subject.—Several experiment stations have made studies of the sweet potato. The Maryland station issued, in October, 1892, a bulletin on the subject prepared by E. H. Brinkley, Assistant Agriculturist. The census shows that North Carolina leads all the States in the sweet potato crop (4,500,000 bushels average annual yield). Georgia, Mississippi, and Alabama follow in the order named. New Jersey stands highest in the average yield per acre. Maryland stands eighteenth in total acreage, thirteenth in yield, and ninth in average yield per acre. The test made by the Maryland station was

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simply with reference to fertilizers, and the largest crop per acre was obtained on sandy loam fertilized with sulphate of potash at the rate of 200 pounds to the acre. The non-fertilized check-plot yielded at the rate of 3,200 pounds.

A more complete paper on sweet potato was issued in December, 1893, by Professor R. H. Price, of the Texas Experiment Station. He states that the total value of the sweet potato crop of Texas is over $1,500,000, and that while the value per acre of cotton is but $15 36, the acre value of sweet potatoes is $50 24. He states that the tops are an important feed for stock, especially for dairy cattle. Thirty-one varieties were tested. He thinks the Vineless one of the best.

Another excellent report upon sweet potatoes came from the Louisiana Experiment Station, and was written by Professors B. B. Ross and H. A. Morgan. This is a very important bulletin, full of details, and includes a careful compilation of historical data respecting the origin and distribution of *Convolvulus batatas*, the true sweet potato. The Louisiana Experiment Station at Baton Rouge undertook to gather an extensive collection of varieties of sweet potatoes, test them thoroughly, and determine the nomenclature, long in a state of utter confusion. It was at this station, in fact, that the renewed interest in this crop began, about 1891.

The Louisiana station tested fourteen varieties at this time. The largest yield per acre was given by the Pumpkin Yam, 331 bushels; Red Nansemond came next with 302 bushels; the third largest was from the Californian, or Shanghai, 276 bushels. Some much more popular varieties for table use, such as the Sugar Yam, Southern Queen, and Norton, yielded at the rate of from 97 to 170 bushels. Some fertilizer experiments showed that on loose, sandy loam (the best soil for sweet potatoes) phosphoric acid was highly profitable, but an excess of nitrogenous fertilizers makes too much growth of vines.

In classification of varieties respecting shape, size, and quality, the system adopted in the Louisiana report leaves nothing to be desired. It must be premised that Northern people usually prefer the dry, starchy varieties, but Southerners favor the sweet and syrupy varieties. There are four distinct types of sweet potatoes: (1) Those that are roundish, and mealy when cooked, as Southern Queen, Red Nansemond; (2) those that are long and slender, and also mealy, as New Jersey Vineless and Spanish; (3) those that are roundish, soft, and very sweet when cooked, as Sugar Yam; (4) those that are long, slender, soft, and sugary, as Georgia Yam.

Trials at the Southern California Station.—A collection of the leading varieties of sweet potatoes was sent to the Station by the Director of the Louisiana Experiment Station in the spring of 1893. The roots were planted in a hot-bed and the sprouts taken off in the usual manner and set in sandy soil, west of the orchard. They undoubtedly received too much irrigation during the summer, as even the varieties naturally mealy were less so than usual. All were unfertilized.

The following notes upon twenty varieties tested are by Mr. J. W. Mills, the foreman of the Station. Samples of each were sent to Berkeley and analyzed by M. E. Jaffa, whose report will be found in the chapter on fruit and vegetable products, on page 220.

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Barbadoes.

Tubers, 7 to 10; regular in shape, uneven in size, small to medium; flesh and skin pale yellow.
Vine, 4 to 6 feet; slender, fibrous; juice colorless; internodes, 1 to 1¾ inches long.
Leaves, 2 to 3½ inches wide; five parted (almost divided), dark green; mid-ribs and cross-veins hirsute beneath, hispid above; two to three at each node.
Petioles, 2 to 2½ inches long.
Product of two best hills weighed 7½ pounds.

Bermuda.

Tubers (only one vine), 14; skin bright reddish-purple; flesh white, brittle; tubers long and crooked (one 2 feet long). Tubers penetrate deeply; roots small.
Vine, 5 to 8 feet long, dark purple, scarcely fibrous; internodes, 2 to 2¼ inches long, smooth; juice slightly milky.
Leaves very dark green, 4 to 5 inches wide; three-lobed, middle lobe long; five-pointed, smooth above and below.
Petioles lurid purple, 4 to 6 inches long.
Product of the hill was 17½ pounds.

Big-Stem Jersey.

Tubers, 6 to 12; average large, regular in size, yellowish white, sprouts easily. Stem rather large.
Vine, 5 to 7 feet long, thick stem, fibrous, slightly purple; milky juice.
Leaves, 3 to 4½ inches broad, almost entire, hirsute.
Petioles, 5 to 8 inches long.
The two best hills yielded 24 pounds.

California (Shanghai).

Tubers, 5 to 8, small to medium, light-colored skin, flesh white; ring of cells ¼ inch beneath skin; exudes milky juice.
Vine, 1½ to 3½ feet long, fibrous, with milky juice in bark; hirsute; internodes, ¾ to 1 inch long.
Leaves, 3 to 4 inches broad, entire, three-pointed; mid-rib faint reddish-purple about one inch from petiole, deepening to intense color down nearly to the petiole.
Petioles, 6 to 8 inches long.
The two best hills yielded 7½ pounds.

Dog River.

Tubers, 5 to 9; flesh and skin carrot-yellow; long, slender, smooth, and above medium size.
Vine, 4 to 6 feet long; thick, glabrous; numerous runners; internodes, 1½ to 2 inches long, fibrous; juice clear.
Leaves, 2 to 2½ inches wide; entire, smooth beneath, hirsute above.
Petioles, 5 to 7 inches long.
The two best hills yielded 9¾ pounds.

Early Golden.

Tubers, 4 to 12; large to small, few being medium sized; breadth greater than length in large ones; large ones with pink blotches.
Vine, 3 to 4 feet long; one fourth of an inch in diameter, very fibrous; juicy, slightly milky.
Leaves, 4½ to 5½ inches broad; almost entire, smooth below, slightly hirsute above.
Petioles, 5 to 9 inches long.
The two best hills yielded 17¾ pounds.

Golden Skin.

Tubers, 5 to 8; small to medium; yellow skin, almost white flesh.
Vine, 3 to 6 feet long; slender, fibrous; internodes, 2 to 4 inches long.
Leaves, about 2 inches broad; entire, three-pointed; smooth beneath, shortly hispid above.
Petioles, 2 to 4 inches long.
The two best hills yielded 5¾ pounds.

Hayman.

Tubers, 4 to 9; small to medium; yellowish white.
Vine, 3 to 3½ feet long, ¼ of an inch in diameter; fibrous, slightly hirsute; milky juice.
Leaves, 4 to 5½ inches broad; entire, with 3 to 4 points, almost smooth above and below.
Petioles, 5 to 9 inches long.
The two best hills yielded 7½ pounds.

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Matejito.

Tubers, 4 to 5; medium size; flesh bright yellowish red, skin light.
Vine, 4 to 7 feet long; very slender, fibrous; thin, milky juice.
Leaves, 1½ to 2 inches broad; hirsute below, hispid above; cauline leaves almost entire, others three-lobed.
Petioles, 2 to 3 inches long.
The best two hills yielded 9½ pounds.

Nameless (label lost).

Tubers, 2 to 4; very large, inclined to crack; skin bright pink, flesh light yellow; rather irregular in shape, inclined to be round.
Vines, 4 to 7 feet long; medium size in diameter, very fibrous; inclined to lurid purple through whole length; juice very thick and milky.
Leaves, 2 to 4 inches wide; nearly entire and three-pointed; mid-ribs and cross-veins purplish beneath, leaves sub-glabrous above and below.
Petioles, 3 to 4 inches long; purple at each end for about three fourths of an inch.
Two best hills weighed 29¾ pounds.

Red Nansemond.

Tubers, 4 to 6; very large; irregular and diversified in shape; yellowish white.
Vine, 4 to 6 feet long; slender for length; medium amount of milky juice; vines slightly purplish; internodes 2 inches long.
Leaves, 2½ to 4 inches broad; purple at union of mid-ribs and petioles; entire to three-parted; smooth beneath and minutely hirsute above.
Petioles, 4 to 5 inches long.
The two best hills weighed 18½ pounds.

Yellow Nansemond.

Tubers, 6 to 16; small and regular; skin yellow, flesh light yellow.
Vine, 2 to 2¼ feet long; slender, fibrous; juice slightly milky; internodes, 1½ to 2 inches long.
Leaves, 2 to 2¼ inches wide; entire; sub-glabrous beneath, hispid above.
Petioles, 2 to 3 inches long.
The two best hills weighed 7¼ pounds.

New Jersey.

Tubers, 6 to 8; medium size, regular, elliptical and pointed in shape; yellow skin; pale yellow flesh; perfect in shape and color, but sprout easily.
Vine, 4 to 6 feet; slender, fibrous, rough; internodes, 2 to 2½ inches long; juice milky.
Leaves, 1¾ to 2 inches wide; entire; smooth beneath, hirsute above.
Petioles, 2 to 4 inches long.
The two best hills weighed 7¼ pounds.

Norton.

Tubers, 2 to 6; large and irregular; skin pink; flesh light yellow.
Vine, 4 to 7 feet long; purple; slender for the length, and very fibrous; abundance of milky juice.
Leaves, about 4 inches broad; lower surface almost smooth, upper surface hispid.
Petioles, 5 to 8 inches long.
The two best hills weighed 19 pounds; one tuber weighed 8½ pounds.

Peabody.

Tubers, 7 to 9; large, round, smooth, fairly regular in size; skin white, flesh pale yellow.
Vine, 4 to 6 feet in length; thick in diameter, medium fibrous; milky juice; generally purple 2 or 3 feet next to root; internodes, 1½ to 2 inches long.
Leaves, 4 to 6 inches broad; smooth above and below; mesophyll rather thick.
Petioles, 4 to 7 inches long.
The two best hills weighed 19½ pounds.

Providence.

Tubers. 2 to 5; large and irregular; skin white, flesh yellowish.
Vine, purple for about 3 feet from root, 4 to 6 feet long; fibrous; juice thick and milky; vine hirsute; internodes, 1½ to 2 inches long.
Leaves, 2 to 3½ inches wide; almost entire, three acuminate points; slightly hirsute above and below; veins purplish.
Petioles, 4 to 6 inches long.
The two best hills weighed 21 pounds; one tuber weighed 8¾ pounds.

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Pumpkin Yam.

Tubers, 4 to 8; large; yellowish white.
Vine, 4 to 6 feet long; thick in diameter, very fibrous; dry milky juice; purple near roots; internodes, 1 to 1½ inches long.
Leaves, 3 to 5½ inches broad; smooth beneath, hirsute above; nearly entire; three-pointed.
Petioles, 4 to 9 inches long.
The two best hills weighed 25¼ pounds.

Southern Queen.

Tubers, 7 to 15; regular and medium in size; skin bright yellow; flesh pale yellow.
Vine, 5 to 7 feet long; slender, fibrous; juice milky; internodes, 2½ to 5 inches long.
Leaves, 2½ to 3 inches broad; three-lobed; hirsute above and below.
Petioles, 4 to 7 inches long.
The two best hills weighed 14 pounds.

Sugar, or Creole.

Tubers, 6 to 12; small; skin light, tinged with pink; flesh light, specked with light brown.
Vine, slender, fibrous; internodes, 1 to 1½ inches long.
Leaves, 1½ to 2 inches broad; five-parted; nearly smooth beneath, hispid above.
Petioles, 1½ to 3 inches long.
The two best hills weighed 3½ pounds.

Tecotea.

Tubers, 1 to 10; long and slender to short and thick; fair to medium in size; skin white, with pink blotches.
Vine, 2½ to 3½ feet long; very numerous and branching, one fourth of an inch in diameter; fibrous, with abundance of milky juice; pubescent; internodes, 2 inches long.
Leaves, 5 inches broad; mostly five-cleft; under and lower part of mid-ribs purplish; lower surface smooth, upper surface nearly smooth. Leaf thin and soft.
The two best hills weighed 12 pounds.

Vineless.

Tubers, 6 to 8; small; skin light yellow; flesh a quarter of an inch below skin is pinkish yellow, interior flesh light yellow.
Vine, 1 to 2½ feet long; thick stem, brittle, granular; juice clear; internodes, ¼ to ¾ of an inch long.
Leaves, 3 inches broad; three to five-parted; scattering, fine hairs on cross-veins beneath; smooth beneath, hispid above.
Petioles, 5 to 6 inches long.
The two best hills weighed 4 pounds.

Quality.—As noted, the vines received too much water, but many varieties proved to be of excellent quality. An expert housekeeper tested a number of sorts, and reported as follows: "The dry potatoes of the Nansemond type are the best for baking, according to the usual Californian ideas, but the soft and sugary yams make by far the best fried potatoes, and ought to be extensively cultivated here. They were a surprise to every one who tasted them." Some separate varieties tested by the housekeeper were reported upon: The Bermudas were "mealy, but lacking in flavor." Pumpkin Yams were "of excellent flavor, but slightly stringy and very soft." Matejitos were "watery, stringy, quite sweet, resembling, when baked, a field squash." Hayman was "very fine flavor, particularly when fried, but too soft when baked." Providence was "of good flavor, very fine in grain, almost without fiber; rather watery when baked; would probably be a very popular variety, especially among those accustomed to Southern cooking."

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F. THE FORESTRY STATIONS.

WORK OF THE STATIONS AT SANTA MONICA AND CHICO.

By C. H. SHINN, Inspector of Stations.

Establishment of Stations.—March 3, 1885, the Legislature of California created the State Board of Forestry, which remained in existence until July 1, 1893. Its history is contained in four biennial reports and in various other publications. According to the State reports, an experiment station was formally established near Santa Monica, December 20, 1887. It was afterwards moved to the tract now in use, which had been deeded to the State for forestry purposes. About this time Gen. John Bidwell offered to give some land on Chico Creek, and twenty-nine acres was afterwards deeded to the State. These two tracts, both fertile and admirably situated, remained in charge of the Forestry Commission during the rest of its existence.

March 23, 1893, the State Legislature, repealing the Act creating the Board of Forestry, ordered that "all the real and personal property of the said Board," on or before the first day of July, 1893, should be "transferred to the Agricultural Department of the University of California." The sum of $4,000 was appropriated to maintain the two stations, one at Chico, the other at Santa Monica, for the two fiscal years ending July 1, 1895.

According to the financial statements of the Secretary of the Board of Forestry, as published in the biennial reports, the total expenditure of the Board upon the two stations was $33,493 40 in fifty-four and a half months, or about $7,400 a year. The third biennial forestry report states that in 1890 there were 15,427 forest trees planted at Chico Station, besides 30,000 small trees in nurseries. No detailed report of the Santa Monica Station was made at this time.

The Stations in June, 1893.—Both the forestry stations were visited in June, to discover their actual condition. Both alike showed weediness, neglect, little or no cultivation, and ravages of stray sheep, cattle, and horses in the young plantations. Only a small proportion of the trees were labeled, and there were no tree registers, nursery books, maps, or memoranda at either station, hence age and history of the specimen trees can only be approximately ascertained.

CHICO STATION.

Taking Charge.—July 1, 1893, the station at Chico was transferred to the University. The tract of twenty-nine acres contained about eight acres in trees and nursery, half of which was in fair condition. The trees were scattered over the tract in isolated groups, and many specimens had been gophered, or girdled by squirrels. Some of these small plantations were so closely set and so overgrown that they were

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practically worthless, it being nearly impossible to make straight, well-grown trees of them.

About 4,000 trees in all were found in plantation form. Of these, 707 were eucalypts, 1,998 pines, 122 maples, 497 box elders; the remainder were chiefly mulberries, catalpas, paulonias, poplars, willows, black walnuts, and umbrella trees. There was one fine block of 76 Sequoia gigantea. After the necessary thinning, the station will have in all about 2,000 well-established trees in plantation form, fit to make excellent growth hereafter and to become typical specimens.

The nursery plot and adjacent territory were covered with Johnson grass. A small tool-shed was on the land. A harrow, cultivator, and a few hand-tools constituted the movable property.

Reorganization of Station.—Colonel C. C. Royce, the general manager of Rancho Chico, consented to act as Patron. Colonel Royce recommended Mr. M. L. Gipson as a suitable person to take the temporary foremanship of the station, and he began work July 2d mowing and burning weeds. Two men were employed at intervals during the autumn to grub out scrub oak, willows, and other wild growth on the tract.

Through the kindness of General Bidwell and Colonel Royce the University obtained the free use of a barn on Rancho Chico near the forestry station; a team of strong horses was rented at a reasonable figure, and hay and grain were purchased. Beginning at the west end, the tract has been deeply and thoroughly broken and all the small plantations have been thinned and well cultivated.

The nursery, owing to the Johnson grass, was wholly worthless for nursery purposes. The deciduous trees were therefore dug and the conifers balled; specimen trees of some sorts hitherto unrepresented were set in the plantation and properly labeled. The surplus was distributed to school districts and various public institutions.

Present Condition.—At the time of this report, the close of the calendar year 1893, the main work of the planting season 1893–94 still remains to be done. If two or three acres can be planted every season with choice trees well cared for and accurately labeled, the Chico arboretum will soon begin to assume shape.

The station tract is nearly level, sloping gently west. It is in the shape of a triangle with the apex pointing east and the base lying parallel to the axis of the Sacramento Valley. The Chico V-flume lies on the southern side; Chico Creek extends along the northern side. A few fine large white oaks remain, and should never be cut. The soil is a red wash from the foothills, mixed more or less with the sedimentary soil of Chico Creek banks. Some gravel patches give variety, and an old Indian mound near the center of the tract gives the usual black, rich, "greasy" soil of such localities. The land is excellently well adapted to forestry purposes, and an immense range of tree growth can be tested here, in time to come. At a conservative estimate the tract is worth $3,000, without improvements, which, as already noted, are unimportant.

Within the past year the main road leading from Chico to the hill country, through the station tract, has been thrown open to the public; the avenue, eighty feet wide from the edge of the town, can be planted by the University with named species of trees. This is especially desired by the townsfolk, particularly by the Normal School people,

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who hope for the speedy development of an attractive arboretum, not only at the station but all the way to town along the V-flume. Although the tract is well fenced (this having been done by General Bidwell), the gates have often been left open by teamsters in time past, and much injury has been done. Since July no sheep, cattle, or horses have been allowed on the station grounds, and as soon as planting begins on the avenue they can be shut out of there also.

Two men and one team are now at work all the time preparing the soil, removing the traces of former neglect, and caring for the trees already established.

Condition of the Plantations.—The Chico plantation, as reported by the Forestry Board in 1890, consisted of the following trees in permanent form:

Name.	No. of Trees.
Eucalyptus viminalis	2,463
Eucalyptus rostata	420
Eucalyptus obliqua	550
Pinus Austriaca	1,652
Pinus pinaster	708
Pinus strobus	984
Pinus insignis	123
Pinus pinea	73
Pinus Torreyana	70
Cupressus sempervirens	1,558
Cupressus Lawsoniana	372
Pseudotsuga Douglassi	470
Thuya occidentalis	228
Sequoia sempervirens	174
Sequoia gigantea	100
Abies concolor	151
Catalpa speciosa	1,188
Negundo Californicum	974
Acer rubrum	763
Acer dasycarpum	306
Salix (osiers)	208
Juglans nigra	210
Juglans rupestris	201
Poplars	160
Fraxinus quadrangulata	57
Betula alba (white birch)	55
Morus alba (white mulberry)	47
Melia azedarach (umbrella tree)	38
Japan maples	24
English hawthorn	9
Weeping elm	6
Araucaria Bidwelli	2
Picea pungens	4
Tilia Americana	4
Magnolias	4
Total	15,437

July 1, 1893, when the University took charge, these extensive plantations had nearly disappeared. Instead of 3,433 eucalyptus, only 707 were found; in place of 3,769 pines, only 1,998; the remainder of the plantation consisted of 122 red maples, 75 Lawson cypress, 16 elms, 8 ashes, 76 Sequoia gigantea, 497 box elder, 312 catalpas, 10 Silver maples, 10 mulberries, and so on. In all, the entire station contained less than 4,000 trees in plantation form. After the necessary thinning out now required, as the trees were originally planted too close together, the Station will begin the year of 1894 with not more than 2,000 trees in plantation, but these will all be fine, healthy, and well established, fit to make a large growth in the next ten years, if continued thinnings give them space to develop.

The Present Plantation.—The present plantation, including the addition of the winter of 1893, now contains representatives of the following species:

Aberia kaffra.
Abies Menziesii.
Abies concolor.
Acacia decurrens.
Acacia melanoxylon.
Acacia longifolia.
Acacia cyanophyllum.
Acer rubrum.
Acer dasycarpum.
Araucaria Bidwelli.
Arbutus unedo.
Betula alba.
Buxus communis.
Buxus aurea variegata.
Carica papaya.
Catalpa speciosa.
Cedrus Deodara.
Celtis occidentalis.
Ceratonia siliqua.
Citrus trifoliata.
Cotoneaster microphylla.
Cornus Nutalli.
Cratægus oxyacantha.
Cupressus sempervirens.
Cupressus macrocarpa.
Cupressus macrocarpa pendula glauca.
Cupressus Lawsoniana.
Eucalyptus viminalis.
Eucalyptus rostrata.
Eucalyptus obliqua.
Eucalyptus pinnata.
Eucalyptus corynocalyx.
Eucalyptus Gunni.
Eucalyptus amygdalina.
Fatsia papyrifera.
Fraxinus quadrangulata.
Gymnocladus Canadensis.
Hicoria alba.
Hicoria pecan.
Juglans nigra.
Juglans Sieboldi.
Juglans Californica.
Juglans (Persian).
Laurus.

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Magnolia fetida (grandiflora)
Melia azedarach.
Morus alba.
Morus multicaulis.
Morus Moretti.
Morus Japonica.
Morus Downingii.
Negundo Californica.
Olea Europæa (named vars. and seedlings).
Olneya tesota.
Pinus Austriaca.
Pinus pinaster.
Pinus strobus.
Pinus sylvestris.
Pinus insignis.
Pinus pinea.
Pinus Torreyana.
Pinus Canadensis.
Pinus ponderosa.
Pinus pinsapo.
Pinus Coulteri.
Pinus Veitchii.
Pinus flexilis.
Phyllea latifolia.
Picea pungens.
Populus monilifera.
Prunus ilicifolia.
Pseudotsuga Douglassi.
Quercus robur.
Quercus suber.
Rhus cotinus.
Rhus Sp.
Salix viminalis.
Sequoia sempervirens.
Sequoia gigantea.
Sterculia platanifolia.
Sterculia diversifolia.
Taxus Hibernica.
Tilia Americana.
Tilia argentea.
Thuya occidentalis.
Ulmus racemosa.
Ulmus (weeping).

SANTA MONICA STATION.

The Location.—The Santa Monica Forestry Station represented the most valuable part of the property of the late Forestry Board. Senator J. P. Jones and the Baker family deeded the land to the State, as was previously mentioned, and more land can probably be obtained whenever it is needed. In point of situation nothing could be finer than the way in which the twenty acres which belong to the station lies on four different levels, and as many slopes, between the branches of Santa Monica cañon. There is a marvelous variety of soil and exposures on the tract, and both the upper and middle mesas overlook the ocean, a mile away. From the town of Santa Monica the distance is two miles and a half, upon a great highway, and thousands of visitors drive through the grounds every season. Rustic cañon itself, on the northern side of the tract, will, in time, justify a great deal of wild gardening, and the naturalization of many flowering plants, such as rhododendrons, azaleas, lilies, etc., that love such rich black leaf-mold, shade, and moisture. The various slopes are fitted for an almost endless range of experiments in form and color. The steep, barren cliff, by which the upper mesa of the tract breaks off suddenly into the cañon on the south, is particularly well suited for gorse, broom, laburnum, and golden acacias. This upper mesa contains about ten acres. The middle mesa, on which the main cottage is built, contains about seven acres. The lowest terrace is a little above the creek; and a small terrace, out of which springs flow abundantly, is half way between the lower and the middle terraces. Even in the very bed of the creek itself, a gravel island protected by willows—a quarter acre or so—contains soil enough for tree planting. Nearly all of the slopes are adapted to vegetation. The total of waste land in the tract is hardly worth considering.

The Eucalyptus Collection.—When the University took charge in July, the following 44 species of Eucalyptus were growing on the plantation:

Eucalyptus hemiphloia.
Eucalyptus robusta.
Eucalyptus eximia.
Eucalyptus amygdalina.
Eucalyptus corymbosa.
Eucalyptus cornuta.
Eucalyptus ficifolia.
Eucalyptus siderophloia.
Eucalyptus platypus.
Eucalyptus eugenoides.
Eucalyptus diversicolor, var. colossea.
Eucalyptus goniocalyx.
Eucalyptus tereticornis.
Eucalyptus macrorhyncha.
Eucalyptus pauciflora.
Eucalyptus regnans.
Eucalyptus leucoxylon.
Eucalyptus rostrata.
Eucalyptus viminalis.
Eucalyptus alpina.
Eucalyptus citriodora.
Eucalyptus corynocalyx.
Eucalyptus rudis.
Eucalyptus globulus.
Eucalyptus Stuartiana.
Eucalyptus saligna.
Eucalyptus Gunni.
Eucalyptus pinnata.
Eucalyptus marginata.
Eucalyptus Planchoniana.
Eucalyptus gomphocephala.
Eucalyptus amygdalina, var. angustifolia.
Eucalyptus leucoxylon, var. rosea.
Eucalyptus Lehmanni, var. strieta.
Eucalyptus occidentalis.
Eucalyptus buprestium.
Eucalyptus polyanthema.
Eucalyptus paniculata.
Eucalyptus calophylla.
Eucalyptus melliodora.
Eucalyptus obliqua.
Eucalyptus resinifera.

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The labels of many of the above trees were lost, and it cost much labor to determine the species. The trees had in some cases been broken down by cattle, and were nearly flat on the ground. Few of them were in any sense fair specimens.

The Larger Plantations.—On the south side of the middle terrace, at the base of a steep slope, a small grove of choice acacias had been planted. This was very handsome at first sight, as some of the trees were twenty and thirty feet high and their branches interlocked, forming a solid mass of green. Upon examination it was found that in this promising young forest many of the trees had been planted in pairs or triplets, to secure a good stand, but that the surplus plants had not been removed. In consequence, there were numbers of cases in which two or three large, strong acacia trees were twisted and interlocked, roots and trunks, utterly ruining their shapely growth. In other cases cattle had broken down the tops, and the result was a mere thicket, like a tangle of willows in a creek bottom.

From four to fifteen rows of eucalypts had been planted around three sides of the highest bluff, and here, also, the need of thinning was at once manifest, though there were many fine trees, particularly of E. corynocalyx.

Taking Charge of the Station.—The University authorities sent Mr. Julius Forrer, foreman of the station at Tulare City, to Santa Monica at the close of June, with written instructions to take charge of the place, map the grounds, list the trees, and do all that was possible to improve the appearance of things, until a foreman should be appointed for the Forestry Station. The foreman of the late Forestry Board for a time refused to surrender the property. The attorney of the Board of Regents notified him to leave, and meantime Mr. Forrer took possession of the large cottage, while the former foreman occupied the small workman's cottage, where he remained till July 17th. The University therefore was not in full possession of the station until the latter date. The new foreman, W. J. Strachan, appointed from the Experiment Station at Berkeley, had arrived July 13th. On the 19th, Mr. Forrer left the station, having performed a difficult task with tact, firmness, and ability.

Former Improvements and Supplies.—When the University took charge, the improvements on the station tract consisted of a small, old stable; a workman's house of three rooms (worth, perhaps, $400); a large lath-house for plants; two water tanks; a hydraulic ram, and the necessary water pipes. Lastly, there was a foreman's cottage of five rooms, which could be duplicated for about $1,200. This cottage is in a very sightly situation at the seaward end of the middle flat. It contained, when transferred, two oak bed-room sets. A pair of farm horses, the two being worth about $150, were turned over to the University. A farm wagon, a few old tools and farm implements, and a set of harness completed the working outfit. An ample supply of pots, labels, laths, and box materials was on hand. Beyond this, the station had little of any value. The first purchases made by the University were hay and horse-feed, a cart and harness, a cultivator, paint for roofs, shakes to repair the stable, and hand-tools for the workmen.

Reorganization of the Station.—Upon the transferring of the station Mr. Henry W. Kruckeberg, editor of the "Rural Californian," of Los Angeles, was appointed Patron, and has shown himself heartily in accord with the plans of the University. It was of course impossible to

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do much to improve the appearance of the station until the rains came. The foreman destroyed weeds, hauled brush, grubbed out stumps, propped up trees in the plantations, and cleared wild land. The upper bluff was broken with four horses and a road plow, harrowed and cross-harrowed. Then it was sown to Nepaul barley, for the double purpose of securing a hay crop and of getting the land into better shape for a future tree plantation. In December four men besides the foreman were actively engaged on the station grounds.

After thinning the eucalyptus plantation in the large oval area south of the cottage (retaining, of course, specimens of every species represented), the acacia grove was thinned and put into shape. The best specimens of trees were selected and open space secured about them. The ground was plowed and stumps and wild growth grubbed out. In a year or two the acacia grove will be a very striking object and some of the wattle bark can be tested for tannin.

Work on the Middle Terrace.—Over the larger part of the middle terrace, east of the cottage and the eucalyptus grove, there has been little planting, and that chiefly consists of the remains of former nursery rows. Half of the eastern end of this plateau was still wild land last July, except for some eucalyptus planted in the brush as an experiment. A portion of it has now been cleared, as it will very soon be needed for new species of trees.

In the old nursery rows, all the trees standing too close for beauty or healthy growth have been removed. An effort is being made to save the camphors which were badly girdled. Three good specimens of Prunus ilicifolia can remain. Two Phyllea latifolia were all that the space would allow. A few trees of Taxodium distichum were badly gophered, and can hardly be saved. Catalpas were abundant, but since they line a part of the main avenue across the grounds, all but one were dug out. Four or five trees of each of the two species of ash were retained. Some butternuts left from an old nursery row were in such shape that five of the best could be kept; the others were moved elsewhere. Good specimens were saved of Acacia retinoides, A. cyanophyllum, and A. longifolia, and also a very pretty and well-grown lot of A. farnesiana. Three good specimens of Quercus cerris, six carobs, a number of mesquite trees (Prosopis juliflora), and a few of the Olneya tesota and Cordia cordata were left in permanent plantation here. At the northern end of this flat were several healthy fruiting specimens of the beautiful pink-flowered Lagenaria Pattersoni. A few plants of walnut, Italian sumac, Sterculia platanifolia, Celtis occidentalis, and one or two other species completed all that this portion of the tract contained. After removing the surplus trees, some were planted on the upper plateau, others on the lowest terrace near the creek, so as to begin a system of comparative tests in different soils and under different conditions.

About thirty black acacias (Acacia melanoxylon) planted as avenue trees on this terrace were so root-bound that they were dying, or could be pushed over by a slight effort. A few of the best were saved for specimens; the rest were destroyed. Fortunately we were able to preserve good trees of all the species of acacia at the station, being more fortunate in this respect than in regard to the eucalypts, for which we had to depend in some cases upon very poor trees of rare species.

The Lower Terrace.—Here we retained a pretty, though long neglected pittosporum hedge by the roadside. Several hedges of Monterey

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cypress, which divided and spoiled the small, rich, level surface, were removed, only leaving a few rods at the western entrance to Rustic cañon. Some overcrowded pines and other trees were cut out, in order to save a fine rosewood tree (Jacaranda mimosæfolia), a Hovenia dulcis, and two araucarias. With these changes, this sheltered oval of sandy soil affords room for many more specimens of important and hitherto unrepresented species.

The Workmen's House.—It was decided to use the three-room house above the slope on the lower terrace for a tool and store house, for which it is admirably adapted. The rough board partitions were taken out, large passiflora vines trained over the walls, a number of small garden beds thrown into a few larger ones, and the endeavor made to treat as a united whole the entire slope, the winding road, the creek bluff and margin, and the picturesque level on which the little house stands. In this part of the grounds there are some very fine native elders, sycamores, oaks, heteromeles, etc., which can easily be preserved, and some very sturdy eucalypti have been planted in the edges of the creek and by the turns of the road.

Water Supply.—From beneath the crest of the northern slope of the middle terrace of the tract, in a thicket of California laurel, oak, willow, and blackberry, there is a constant though small flow of water. This was rudely developed some time ago by cross ditches; it is now being developed systematically by two lines of drain tile, with tributary branches on the upper side. The water from this valuable spring is carried across the road to the small cottage, goes into a 2,000-gallon tank, giving it sufficient fall to drive a hydraulic ram which lifts a portion to another tank on the middle terrace. If the lower tank is kept full, 205 gallons of water can be delivered 12 feet above the base of the upper cottage in one hour and five minutes. The ram is supplied through a 3-inch pipe 119 feet long, having a vertical fall of 12 feet 5 inches. The waste water is of some use for irrigation in the cañon. The system is cheap and probably will supply all the water needed for the house and garden. At one time there was a flume extending up the cañon, so as to increase the supply to the ram, but this, not being secured in any manner, was washed out by the winter freshets. It is believed that the springs on the tract will furnish an ample supply. The tanks have been pumped out and cleaned of a foot or two of debris and sediment. A good deal of inch pipe was formerly laid in the nursery and in other parts of the grounds. With some needed changes the water system will probably prove reasonably satisfactory. It must be understood that trees on the highest plateau must always be grown without irrigation, trees on the middle terrace can receive if necessary a little water while small, but the lower terrace can be fairly well irrigated in case of need.

Additions to the Plantations.—In many cases species already planted in one place have also been planted in other plateaus of the tract. In addition to whatever has been mentioned in the preceding pages, as found on the grounds when the University took charge, there are now representatives of the following species in the plantations, besides others not yet placed in permanent form:

Palms.

1 Phœnix reclinata.	1 Sabal palmetto.	1 Chamærops excelsa.
1 Phœnix Canariensis.	1 Kentia Fosteriana.	1 Areca Baueri.
1 Phœnix tenuis.	1 Kentia Balmoreana.	1 Dracena draco.
14 Phœnix dactylifera.	1 Kentia Canterburyana.	

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Oaks.

30 Quercus pedunculata. 2 Quercus rubra. 4 Quercus suber.

Evergreens. (Broad-leaved.)

1 Cinnamonum Loureiroi.
1 Oonshiu orange.
2 Aberia kaffra.
1 Buxus aurea.
1 Buxus sempervirens.
2 Psidium Cattleyanum.
1 Pittosporum rugosum.
1 Litchee.
Ilex (in variety).
1 Photinia eriobotrya.
1 Melaleuca.
1 Lycium Andersoni.
1 Lytrs caustica.
1 Edwardsia McNabiana.

Evergreens. (Conifers.)

1 Sciadopythis verticillata.
2 Cryptomeria Japonica.
1 Retinospora ericoides.
1 Araucaria Braziliensis.
2 Larix Americana.
2 Larix Europæa.
1 Pinus ponderosa.
1 Pinus pinsapo.
1 Pinus Canadensis.
1 Abies Veitchii.
1 Abies Menziesii.
2 Taxus Hibernica.

Bamboos. (In variety.)

Vines and Trailers.

Stauntonia hexaphylla. Mandevillia suaveolens. Climbing roses.
Tecoma jasminoides. Cobæa scandens. Trailing cypress.

There are also small specimens of many other evergreens still in pots or in the nursery.

Deciduous Trees and Shrubs.

1 Acacia julibrissin.
2 Castanea vesca.
2 Castanea sativa.
1 Liriodendron tulipifera.
1 Liriodendron integrifolium.
1 Malus carda.
1 Juglans regia.
1 Juglans regia (variety Kaghazi).
1 Juglans Sieboldi.
2 Gleditchia tricanthos.
1 Fraxinus excelsa.
2 Fraxinus Americana.
2 Fraxinus Ornus.
2 Fraxinus (water ash).
2 Sorbus Europæa.
1 Colletoa spinosa.
1 Kolreuteria paniculata.
6 Pyrus Japonica.
Morus in variety.
1 Elæococca cordata.
2 Eleagnus longipes.
100 Betula alba.
2 Betula nigra.
2 Prunus serotina.
2 Prunus spinosa.
2 Acer campestre.
2 Acer saccharinum.
2 Acer plantanifolium.
1 Caragana arborescens.

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III.

REPORTS ON ENTOMOLOGY AND PLANT DISEASES.

A Laboratory of Plant Diseases.
Root Knots on Fruit Trees and Vines.
Experiments in Winter Spraying of Apples and Pears.
Remedies for Plant Diseases.

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REPORTS ON ENTOMOLOGY AND PLANT DISEASES.

A LABORATORY OF PLANT DISEASES.*

By C. W. Woodworth.

There has recently been equipped at the University of California a laboratory for the study of the subject of plant diseases in its broadest sense; and as there are but few if any others where the subject is taught as a unit, it may be well to give an outline of the equipment for this class of work.

We will not consider that part of the equipment for the work afforded by the grounds, orchard, nursery, gardens, and greenhouses of the Agricultural Department, but confine ourselves to the laboratory proper. The subject of plant diseases is now and will continue to be associated with that of entomology, so that the same equipment, to a considerable extent, serves for the two subjects.

The laboratory room is something over 20 by 30 feet, and is situated on the north side of the Experiment Station building. It is lighted by four windows, having an entirely unobstructed view, and so giving ample light for microscope work. A corner of the room is partitioned off for a private laboratory, and a closet is fitted with a ruby window, affording an opportunity for photo and blue print work.

The windows are all fitted with heavy shades working in grooves, enabling one to darken the room very easily and quickly when the lantern is to be used for illustration. The views are projected on a screen of tracing cloth, which is mounted on a common spring-roller and is ordinarily rolled up out of the way.

Besides the benches near the windows, which are used by advanced students, there are also three long desks, 1½ feet wide by 12 feet in length. These are so constructed that at the side of each student, boxes, the size of those in the collection, may be used as drawers, or boards may be inserted, forming shelves.

The boxes used for the collection are so made as not to be liable to warp or crack, and so remain perfectly insect proof. A cloth bearing for the glass is treated with corrosive sublimate, and the paste and glue used are arseniated. These boxes are kept in cabinets, the glass doors of which are fitted with a rabbeted groove on all four sides, thus making them also dust and insect proof.

The collection kept in these cabinets are arranged in three series. Series one is the systematic collection where the organisms producing injuries are grouped in the ordinary order, beginning with mammals and ending with the highest plants. The second series is the "host" collection, where the various plants are taken up in an agricultural order, as, for instance, seed crops, fruit crops, etc., and the injuries to each peculiar crop illustrated. In the third series, the symptomatic

* Science, December 30, 1892.

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collection, all diseases having a common symptom are brought together, thus all galls and the distortions, from whatever cause or on whatever plant, are assembled and classified.

Besides these there are the beginnings of a cryptogamic herbarium in drawers, and a collection representing the materia medica of plant diseases. There are in the laboratory a sterilizer and all the other necessary apparatus for this class of bacteriological work. For microscopical and histological work there is also a good equipment, including paraffin bath, microtome suitable for the highest grade of work, compound microscopes and accessories, and a very good outfit of reagents. All reagents, as far as possible, are kept in standard strengths, and the bottles marked to serve as graduates for dilution. Thus the chromic acid is made up in a large bottle into a 5 per cent solution. The 1 per cent solution is made by filling a smaller bottle to a certain mark and adding water. Most of the chromic mixtures are made from the 1 per cent. The chromic-acetic killing mixture, for instance, is made as indicated on the label: from one half per cent chromic acid to the first mark, 95 per cent alcohol to the second, and 10 per cent acetic acid to the neck. Mixtures liable to deterioration are kept in very small bottles, and such as the acid alcohols are not kept mixed at all, but large homo vials are properly labeled and graduated and the mixtures made up as used. This sketch gives merely the present condition of the laboratory. It is expected that apparatus will be added from time to time, as opportunity offers, and as it is needed for the work in hand; indeed, there is considerable new apparatus at the present time being constructed for the laboratory.

ROOT KNOTS ON FRUIT TREES AND VINES.

By C. W. Woodworth.

Introductory Note.—The subject upon which Professor Woodworth makes the following interesting statement has perplexed California fruit-growers for many years. Almost everything imaginable has been cited as a probable cause; conditions of drought or of excessive moisture were among the earliest causes assigned, and some prejudice against nursery stock grown by irrigation was created. An investigation by a committee of the State Horticultural Society about 1880 showed that the knotted roots were found quite as abundant in unirrigated land as in irrigated, and otherwise the inquiry yielded no definite results. For some time many nurserymen followed the practice of removing the knots from the trees as dug from the row, but this was abandoned when it was found that the knot commonly reappeared after planting in the orchard. At present no reputable nurseryman sells such trees; they are burned at the nursery.

In my personal examination of knots, which has continued for fifteen years, I have but on one occasion found a nematode gall, and that was upon the root of an English walnut sent from Los Angeles County. Nearly all the others were of the character described by Professor Woodworth as "crown galls," although they are found in many cases farther down on the roots. Some orchardists have been at great expense in laying bare the roots and smoothly paring them and applying various substances to the wound. In most cases the knots have reappeared subsequently. Others have laid bare the knot-burdened root-crown to the sun and the knots have flaked off, but other knots have been found afterward lower down on the roots.

It must be acknowledged that the cause of the evil and its cure are still unknown, and it is to be hoped that Professor Woodworth's study of the subject, which is still in progress, may reach definite conclusions. His advice not to plant a diseased root should be zealously adhered to by all planters. Probably during the last twenty years hundreds of thousands of such trees have spindled and died in the best soil and with the best treatment. If the disease has stunted the growth of a young tree, pluck it out and plant a new one. If knots are found on larger trees, which are making satisfactory growth in spite of them, remedial measures should be tried. The final result seems to depend upon whether the natural or diseased growth secures the ascendency early in the life of the tree, for apricot trees have been taken up after thirty years of satisfactory growth and bearing, and found to have roots badly infested with the knots. (E. J. Wickson.)

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Distribution.—There is no one thing about which so many inquiries have been received as a peculiar form of root knot or gall on a number of plants, chiefly grape and apricot. It seems to be much more injurious in this State and in Arizona than elsewhere, though it occurs in all parts of the country and in Europe, more or less abundantly. These knots are of irregular shape, fleshy and mostly situated at or about the crown of the roots. On different plants they present a somewhat different appearance, but they are so near alike in structure as to prove that they must all be due to practically the same causes. I have studied the gall on apple, peach, plum, prune, apricot, cherry, grape, blackberry, and hop.

Confusion of Names.—This form of gall has received a number of local names, the most widely used of which is that of "black knot," particularly for the form that occurs on the grape. Since the publication of Bulletin No. 99 by this Station, the subject has been much discussed in horticultural societies and in the press of the State, and the term black knot has been quite generally adopted. This name is objectionable, as was there pointed out, as it has long been used in the Eastern States for a very different kind of gall that occurs on the stems of cherries and related fruits; and, moreover, our knot is not black but light brown at first, becoming dark brown, but never black. On account of its presence almost always at the crown of the root, the term crown gall or knot was suggested, and is a good name, as other forms of gall seem to show as decided a preference for other parts of the root as this does for the crown.

The Crown Gall.—The crown gall is by no means invariably at the crown. They are often very abundant at the point where the roots were cut by the digger when they were removed from the nursery, or where they were bruised in setting. Insects may also cause the appearance of the crown gall lower down on the roots, as will be shown below. The crown knot only appears below the service of the ground, so far as known, except in the grape, where it is sometimes just above the ground. Some forms of excrescences occurring on the trunk and branches have often been supposed to be the same as the crown knot.

Galls above Ground.—The following have been confused with the crown knot:

(1) *Mechanical galls*, which are slight swellings produced in the healing of wounds, or where repeated bruisings occur, as in case of crossed limbs. They generally have a smooth surface, which will at once distinguish them from crown knots; and the structure is entirely different.

(2) *Gnarls*, which while small consist of a free, hard, woody kernel beneath the bark, but later become attached to the wood of the trunk and ultimately disappear through the growth of the trunk. They are generally explained as being latent buds which have started to grow, but perhaps from the death of the axial cell have been unable to produce a shoot, but continue to grow and make wood. The cause or condition of their production is a matter of which we are quite ignorant, but as to their difference from the crown knot there is no doubt, and structurally they have scarcely anything in common.

(3) *Twig galls*, found on many plants, especially the quince, where they are so uniformly present as to be generally regarded as normal structures. They are generally smaller than the crown knots and much

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rougher, and differ in their manner of growth, appearing hard from the first.

The crown galls arise generally from one side of the crown as a simple swelling of fleshy substance of about the consistency of a potato, or perhaps somewhat harder. They soon become irregularly granular over the surface and dark brown in color, the outer parts of the granulations into which the surface is divided being the darkest. When cut or broken open they are almost white at first, but very soon become reddish brown on exposure to the air. Under the microscope they may be seen to be composed of large, thin-walled cells, with now and then the distorted and scattered elements of the fibro-vascular bundles.

A young gall of this kind contains very much water, and if dried becomes sponge-like and is very light, though quite hard and often cracked radially. When attacked by fungi while still young the knot will take on this appearance after a time. Older knots are harder, and dry into harder and firmer masses, which do not shrink or become sponge-like. In size the crown gall varies greatly, being often as large as one's fist and sometimes much larger, especially in the apricot.

Other Root Galls.—Of other root galls, we may distinguish five different kinds:

(1) *Mechanical galls*, which are slight swellings, sometimes produced at points where the roots meet obstructions, and are quite common on the roots of some plants in a stony soil. They may be told at once from a crown gall by their comparatively smooth surface, and by the fact that they only accompany an abrupt bend of the root. They are only slight swellings and flattenings of the root, and are seldom found anywhere near the crown. Indeed, they are the form of root gall least likely to be mistaken for the crown gall.

(2) *Louse gall*, due to the attacks of plant lice. Those caused by the phylloxera and woolly aphis are well-known examples. They are almost always of small size, occurring on both large and small roots, and as often at the crown as elsewhere. The presence of the lice is generally sufficient as a distinguishing character, though their small size may render them hard to be seen.

(3) *Tubercle galls*, found only on the roots of plants of the pea family. Only the smaller roots are affected. The gall is about an eighth of an inch or less in diameter, the whole inside of which is swarming with minute moving particles, which appear to be bacteria. They play an important rôle in the acquisition of nitrogen from the air by the plant. The small size of these galls and their presence only on the small roots will distinguish them from the crown galls.

(4) *Club-foot galls*, produced by a slime-mold (*Plasmodium brassicæ*), on the roots of cabbages and similar plants. These galls are somewhat yellowish when broken open, which color is due to the presence of the slime-mold in great abundance in the diseased tissues of the gall. They may be distinguished from the crown galls by not being so knot-like, but being much more closely attached to the plant.

(5) *Nematode galls*, which are due to minute worms resembling very much the so-called vinegar eels. They are found on the roots of a great number of plants. The worms are so small that ordinarily they will not be seen without examining sections under the microscope. The small size of the gall, and its presence chiefly on the smaller roots, will distinguish it from the crown gall.

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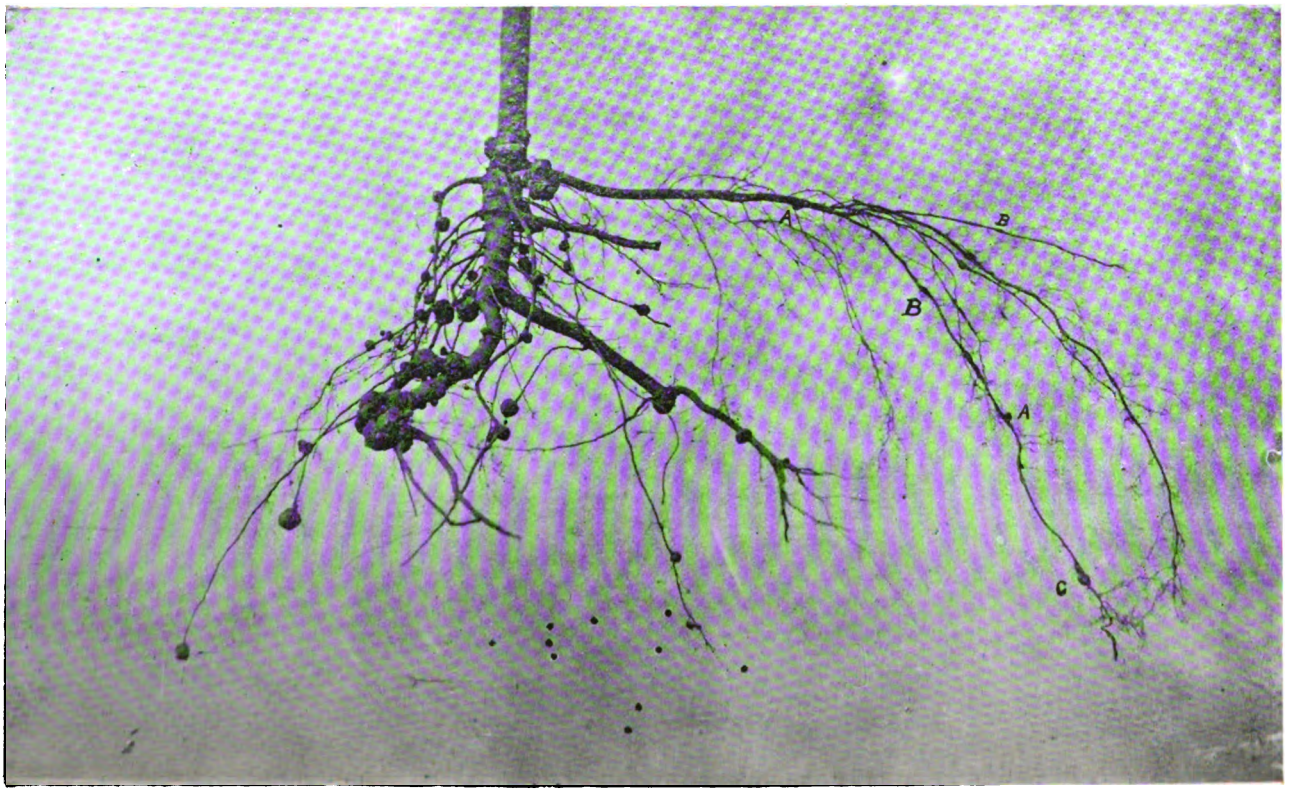

Apple Root, showing Crown Knot (AA), Woolly Aphis Galls (BB), and a Gall (C), illustrating both forms.

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Cause of Crown Gall.—There are several theories as to the cause of the crown gall, but none of them are without very serious objections. One idea is that these galls are the result of wounds made in cultivation, and there is no doubt but that the galls have followed such wounds. In attempting to heal a wound, as is well known, the plant will often produce at that point a slight swelling, and it is argued that at the crown the conditions are such that a large swelling will result. There are, however, a number of fatal objections to this hypothesis. Neither is the crown gall the uniform result of a wound; nor is a wound, at least one made by human agency, necessary to produce a gall, though it would be bold to assert that there had never been a wound of any kind at the point where the gall is produced. The most fatal objection to this hypothesis is the fact that the appearance, the manner of growth, and all the phenomena connected with the crown gall are so different from those of a healing wound that there seems scarcely any reason to connect the two.

Another theory is that they are due to peculiar conditions of the weather, such as frosts, excessive rains, and such things at a critical time in the spring; these cause an abnormal stagnation or an excessive flow of sap, and the gall is the result. It is a well-known fact that excessive sap pressure will produce abnormal growth of parts of the plant, but nothing comparable with the crown knots. Indeed, these suppositions are scarcely reconcilable with the facts of plant physiology, and it has never been observed that these galls are produced in particular abundance immediately following any peculiar spring condition. It would seem that the idea arose from the general tendency to ascribe every abnormal condition of a plant to the weather.

A third theory is that they are due to some of the fungi related perhaps to that which produces the true black knot. The only objection to this theory is that no such fungus has ever been observed about the knots, at least not in the living knots, and it may be that a more careful study than has yet been made will show that such fungus does occur.

Finally, as has become quite the fashion of late years, the bacteria have been charged with the injury. I myself have succeeded in getting pure cultures of a micrococcus from the inside of some of the knots, after taking all the usual precautions to prevent accidental contamination. This, however, is by no means conclusive, but there is a great deal of evidence that the gall is an infectious disease of the plant. The accompanying figure is from a photograph of the roots of one of a number of similar young apple seedlings grown in the University nursery. It was badly infested with woolly aphis, but the galls upon which they lived were not like those generally produced by this insect, but were in every respect true crown knots. The seedlings were two years old and transplanted when one year old. At this time they were free from the aphis, but some had the knots at the crown. After they became infested with the aphis those having old crown knots became knotty all over the roots, as in the one photographed. To make the evidence still more striking, a very few of the galls were typical woolly-aphis galls, and these were in every instance in such a position that the lice would have naturally reached the spot in walking down the stem without coming in contact with the gall. Galls of this kind are shown at BB, typical crown knots at AA, and at C one that in part resembles the crown knot

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and in part the woolly-aphis gall. In another specimen the woolly-aphis gall occurred only on a root given off above the knot.

Effect of Crown Knot.—The presence of a gall at the crown while it remains alive seems to affect the plant but very little, but later it will produce injury in one or two ways: First, the gall presenting a mass of dead tissue for the various semi-saprophytic fungi which only seem able to become parasitic after gaining a foothold in some dead tissue, and so become able to overwhelm the plant; or second, the dead gall, if not too deep below the surface of the ground, will dry out, as will the adjacent parts of the stem. If this drying process proceeds beyond a certain point the water supply for the leaves will be insufficient, and the plant will die as if by drought. The gall generally attacks small plants, but not always, and it often takes a number of years before the plant is killed.

The crown knot has come to have a legal aspect through the work of the Horticultural Commissioners. Nursery stock which is attacked by the knot is condemned and destroyed. In addition to this it would be well if it was required to dip in Bordeaux mixture all stock which has come in contact with knotty trees, as it is probable, though not certain, that the disease may be conveyed in this way. It is quite certain that tools used in digging do convey the disease.

Remedies Suggested.—Whatever the cause, many fruit-growers in California have had reason to know the seriousness of the injury produced, so the following words in regard to remedies and prevention will not be out of place. A number of experiments that have come under my observation go to show that the knots can be successfully removed from trees in the orchard when they occur only at the crown. Care must be taken to treat all places touched by the hoe in unaffected trees examined, as well as those from which the knots are removed. The following treatment is recommended:

First—In the orchard the knots should be carefully removed and burned as soon as found, and an antiseptic application made to the tree where the knot has been removed. We would recommend Bordeaux mixture for this purpose. Trees so treated should be examined from time to time for at least a year, and should the knot reappear, it would be best to remove and destroy the whole tree. When a tree is removed, it would be well to delay resetting for a year or two, or to reset with a tree of an unsusceptible kind.

Second—When setting an orchard, reject all stock affected by the knot. I would prefer to have stock from a nursery known to be entirely free from it, though I have reason to believe that no nurseries in this State are absolutely free from it. It would be a good plan to dip all the trees in Bordeaux mixture before setting.

Third—In the nursery the greatest care should be taken to destroy by burning everything showing any sign of the disease, and the dipping of all stock in Bordeaux mixture as soon as dug is recommended. Fields in which these galls have appeared should be devoted to some other crop for a number of years.

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EXPERIMENTS IN WINTER SPRAYING OF APPLES AND PEARS.

By C. W. Woodworth.

The ranch of a generation ago in becoming the farm or orchard of to-day retains its old name and to a considerable extent its old practices. As the sheep began to be replaced by fruit trees the old sheep-dip became the tree-wash. This is the pedigree of one of our standard washes, the lime, salt, and sulphur mixture, and in this case it has proven itself a very useful remedy. The present article is written as a protest against the blind use of this and other washes inherited from other days, for as the sheep were all regularly dipped so it is the common practice in this State to apply a wash of some kind, upon general principles, each winter or spring, while the tree is dormant, with no regard to the condition or need of the tree. Venders of patent washes and often horticultural commissioners advocate this practice, and many among the most progressive fruit-growers consider it safer to follow the custom, though orchardists are by no means unanimous in their approval of it.

There are many who do not believe in spraying trees at all, including those too lazy to do so, those who believe in the sufficiency of natural checks, and those who are waiting for imported parasites; and on the other hand as representing the other extreme, there are many who wash their trees persistently and regularly, believing that in this way only can insects and fungi be kept from becoming excessively abundant and injurious, or who have the idea that the wash acts in some way directly on the tree as a medicine, making the tree more healthy.

The experiments herein reported were undertaken under the impression that the common practice was sound, and the object was to compare a number of washes, especially those commonly used in this State and in the East, and also the effect of the addition of arsenic to the washes. For these purposes these experiments were entirely negative in their results, but they do show plainly certain facts bearing upon the question of tree washing in general.

Description of the Experiments.—A plot of the orchard in which the experiments were conducted is shown in the accompanying figure, which will give at a glance the plan of the experiments. The size of the trees as indicated on the plot by the size of the circles will give quite accurately their physical condition, except that some of the smaller circles represent young trees instead of decrepit old ones. The trees marked as dead are those which have died or have been removed on account of their unhealthy condition up to the date of this report. This loss of trees seems to have been in a good part due to injury to the bark of the trunk and larger branches done when the strong caustic washes were the fashion. Among the apple trees another cause also operated in making the heavy mortality. Certain of the common toad stools gaining entrance through the excrescences on the roots caused by the woolly aphis were able to effectually kill many of the trees. The

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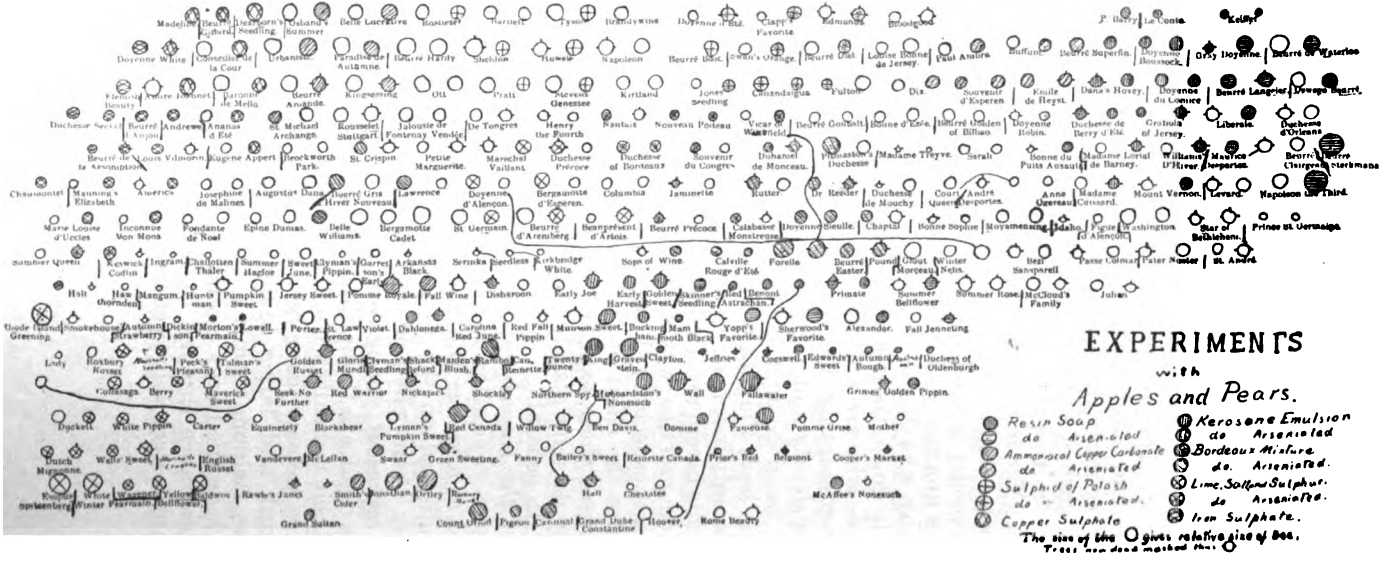

Plot of the Orchard at the Experiment Station, Berkeley.

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relation of this mortality to the treatments is a matter of some interest and is shown in the following table:

	Treated.			Untreated.			Total.		
	No. of Trees.	No. Dead.	Per cent Dead.	No. of Trees.	No. Dead.	Per cent Dead.	No. of Trees.	No. Dead.	Per cent Dead.
Apples	104	32	30	96	39	40	200	71	35
Pears	117	23	20	148	35	24	265	58	22
Totals	221	55	24	244	74	30	465	129	27

The decidedly less amount of death in the treated trees is not to be explained as the result of the treatment, but the difference is caused by the fact that the worst trees were always left untreated. This is easily proven, since of 72 varieties selected at the time the application was made, in which the two trees of each variety were to all appearances in equally good condition, and in which one was treated and the other left untreated as a check, exactly one half of those that died were treated and one half untreated; that is, of 72 treated trees 20 died, and of 72 untreated trees of the same varieties 20 also died.

The following tables give in detail the records of the experiments:

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TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH APPLES.

Name.	Record Before 1892.			Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.		Woolly Aphis. 1894.
	Growth.	Woolly Aphis.	Yield.	Growth.	Oyster-Shell Scale.			Growth.	Oyster-Shell Scale.	Growth.	Oyster-Shell Scale.	
Grand Sultan				good	fair	AACC	good	small	fair	good	none	none
Count Orloff	small	much	small	good	little	ABM	good	good	little	good	little	little
Pigeon				good	little	ABM		good	little	good	little	little
Cardinal	fair	little	small	good	little	ABM		good	little	good	fair	little
Grand Duke Constantine	small	much	fair	good	little	none		fair	fair	good	fair	fair
Hoover*						none	few	good	fair	good	fair	little
Hoover*						none	few	good	fair	dead		
Rome Beauty*	fair		small	good	fair	none	good	good	fair	good	fair	fair
Rome Beauty*	fair		small	good	little	none	good	good	little	dead		
Esopus Spitzenberg	good	little	small	good	fair	LSS		good	fair	good	fair	fair
White Winter Pearmain	strong	little	good			LSS		good	little	good	fair	fair
Wagener	fair	little	small	good	little	LSS		good	little	good	little	fair
Yellow Bellflower	strong	much	small	good	fair	LSS		good	little	good	little	fair
Baldwin	fair	little	small	good	fair	LSS		good	little	good	little	fair
Rawle's Janet						AACC		good	little	dead		
Smith's Cider	strong	none	good	good	little	AACC		good	little	dead		
Smith's Cider	strong	none	good	good	little	AACC		fair	little	good	little	little
Jonathan				good	fair	AACC		good	fair			
Ortley	fair	much	good	good	fair	AACC	fair	good	fair	good	fair	fair
Roxbury Russet	strong	much	good	good	little	none	good	good	fair	dead		
Northern Spy				good	fair	ABM	good	good	fair	dead		
Hall	small	bad	fair	good	fair	ABM	fair	good	little	dead		
Chestatee				good	little	none	little	good	fair	good	none	none
Chestatee				good	little	none	little	good	little	good	none	none
McAffee's Nonesuch				good	fair	ARS	heavy	good	fair	good	little	fair
McAffee's Nonesuch						none		good	fair	dead		
Dutch Mignonne	fair	much	good	fair	fair	LSS		fair	fair	good	fair	fair
Dutch Mignonne	fair	much	good	fair	fair	LSS		fair	fair	dead		
Wells' Sweet				good	fair	LSS		good	fair	good	fair	fair
Wells' Sweet				good	fair	LSS		good	little	dead		
Marshall's Lewelling†				good	little	LSS		good	little	good	little	little
English Russet	fair		small	good	fair	none	fair	good	fair	good	little	fair
Vandevere	strong	little	fair	good	fair	none	good	fair	fair	good	fair	fair
McLellan				good	much	ACC	heavy	good	much	good	fair	little

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Swaar	good	little	fair	good	fair	ACC	.....	good	fair	good	fair	fair
Swaar	good	little	fair	good	little	none	.....	good	little	dead	.....	.....
Green Sweeting	.....	.....	.....	fair	little	BM	.....	fair	fair	dead	.....	.....
Fanny*	fair	much	fair	good	fair	none	good	fair	fair	dead	.....	.....
Fanny*	fair	much	fair	good	fair	none	fair	fair	fair	good	fair	little
Bailey's Sweet	.....	.....	.....	good	little	none	.....	good	little	good	little	fair
Reinette Canada	fair	little	fair	.....	.....	KE	.....	poor	little	dead	.....	.....
Reinette Canada	fair	little	fair	good	little	KE	.....	fair	little	good	fair	little
Prior's Red	.....	.....	.....	good	little	KE	good	fair	much	good	fair	fair
Prior's Red	.....	.....	.....	good	little	KE	.....	good	fair	dead	.....	.....
Belmont	fair	bad	small	good	little	ARS	.....	good	little	dead	.....	.....
Cooper's Market	.....	.....	.....	good	fair	ARS	little	good	fair	good	little	fair
Cooper's Market	.....	.....	.....	good	little	ARS	.....	good	fair	dead	.....	.....
Duckett	fair	little	good	good	little	none	good	good	fair	good	little	fair
Duckett	fair	little	good	good	little	LSS	heavy	good	little	good	little	fair
White Pippin	fair	.....	small	good	fair	LSS	heavy	.....	.....	good	little	fair
White Pippin	fair	.....	small	.....	.....	LSS	heavy	fair	fair	dead	.....	.....
Carter	.....	.....	.....	good	little	none	.....	good	little	good	little	fair
Carter	.....	.....	.....	good	fair	none	.....	good	fair	dead	.....	.....
Equinetely	fair	much	good	good	little	none	little	good	little	good	little	fair
Equinetely	fair	much	good	good	little	ACC	little	good	little	dead	.....	.....
Blackshear	.....	.....	.....	good	little	ACC	.....	good	little	dead	.....	.....
Lyman's Pumpkin Sweet	.....	.....	.....	good	little	none	.....	good	little	good	fair	fair
Lyman's Pumpkin Sweet	.....	.....	.....	good	little	none	.....	.....	.....	dead	.....	.....
Red Canada*	.....	.....	.....	good	little	BM	.....	good	little	dead	.....	.....
Red Canada*	.....	.....	.....	good	little	none	.....	fair	little	good	little	fair
Willow Twig*	.....	.....	.....	good	little	none	.....	good	fair	good	little	fair
Willow Twig*	.....	.....	.....	good	fair	none	.....	good	fair	dead	.....	.....
Ben Davis*	fair	bad	small	good	much	none	good	good	much	good	little	little
Ben Davis*	fair	bad	small	good	fair	none	good	fair	fair	dead	.....	.....
Domine	.....	.....	.....	good	fair	KE	small	good	little	good	fair	little
Fameuse*	.....	.....	.....	good	fair	none	fair	good	fair	dead	.....	.....
Fameuse*	.....	.....	.....	good	fair	KE	fair	good	fair	good	fair	fair
Pomme Grise	.....	.....	.....	.....	.....	none	.....	dead	.....	dead	.....	.....
Pomme Grise	.....	.....	.....	.....	.....	none	small	.....	.....	good	fair	fair
Mother	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Mother	.....	.....	.....	.....	.....	none	.....	.....	.....	good	fair	fair
Golden Russet	.....	.....	.....	.....	.....	none	.....	good	fair	good	little	fair
Cullasaga	.....	.....	.....	good	fair	LSS	small	fair	fair	good	little	fair
Berry*	strong	much	fair	.....	.....	none	good	good	fair	dead	.....	.....
Berry*	strong	much	fair	good	little	LSS	fair	good	fair	good	little	fair
Maverack Sweet*	.....	.....	.....	.....	.....	none	.....	good	little	dead	.....	.....
Maverack Sweet*	.....	.....	.....	.....	.....	LSS	.....	none	fair	good	fair	fair
Seek No Further*	fair	much	small	.....	.....	none	.....	.....	.....	good	fair	fair
Seek No Further*	fair	much	small	good	bad	ACC	.....	good	bad	dead	.....	.....

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TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH APPLES—Continued.

Name.	Record Before 1892.			Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.		Woolly Aphis. 1894.
	Growth.	Woolly Aphis.	Yield.	Growth.	Oyster-Shell Scale.			Growth.	Oyster-Shell Scale.	Growth.	Oyster-Shell Scale.	
Red Warrior*	.....	.....	.....	good	little	ACC	.....	.....	.....	good	fair	fair
Red Warrior*	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Nickajack*	strong	much	fair	good	fair	ACC	.....	good	fair	dead	.....	.....
Nickajack*	strong	much	fair	good	little	none	.....	none	bad	good	fair	fair
Shockley	.....	.....	.....	good	little	BM	.....	good	little	dead	.....	.....
Shockley	.....	.....	.....	good	fair	none	.....	good	fair	dead	.....	.....
Northern Spy*	.....	.....	.....	good	fair	none	good	good	fair	good	none	none
Northern Spy*	.....	.....	.....	fair	fair	none	good	fair	fair	dead	.....	.....
Hubbardston's Nonesuch	strong	bad	small	fair	fair	KE	.....	none	fair	good	fair	little
Wall*	.....	.....	.....	good	much	KE	.....	fair	much	dead	.....	.....
Wall*	.....	.....	.....	good	much	KE	.....	fair	much	good	fair	fair
Fallawater	.....	.....	.....	fair	fair	KE	good	fair	fair	dead	.....	.....
Fallawater	.....	.....	.....	.....	.....	RS	.....	.....	.....	good	fair	fair
Grimes' Golden Pippin	fair	.....	small	.....	.....	RS	.....	.....	.....	dead	.....	.....
Grimes' Golden Pippin	fair	.....	small	.....	.....	RS	.....	.....	.....	good	fair	bad
Lady	.....	.....	.....	fair	little	none	.....	fair	little	good	little	fair
Roxbury Russet*	strong	much	good	good	fair	none	good	good	fair	good	fair	fair
Roxbury Russet*	strong	much	good	.....	.....	LSS	good	good	fair	dead	.....	.....
Marshall's Seedling †	.....	.....	.....	good	little	LSS	.....	good	little	good	none	none
Peck's Pleasant	.....	.....	.....	fair	fair	LSS	.....	good	fair	good	little	bad
Talman's Sweet*	fair	.....	small	good	little	LSS	little	good	little	good	fair	little
Talman's Sweet*	fair	.....	small	fair	little	none	.....	fair	little	dead	.....	.....
Golden Russet*	.....	.....	.....	good	fair	LSS	good	good	fair	good	little	little
Golden Russet*	.....	.....	.....	good	fair	ACC	.....	good	fair	dead	.....	.....
Gloria Mundi	.....	.....	.....	.....	.....	none	.....	good	little	good	fair	fair
Clyman's Seedling	.....	.....	.....	good	fair	ACC	.....	good	fair	good	fair	fair
Shackleford †	.....	.....	.....	fair	little	none	.....	fair	little	.....	.....	.....
Maiden's Blush	fair	much	fair	fair	fair	none	little	good	fair	good	fair	fair
Rambo	strong	much	small	fair	fair	BM	.....	fair	fair	good	little	fair
Canada Reinette	fair	little	fair	good	little	none	.....	none	fair	good	little	little
Twenty-Ounce	small	.....	fair	good	fair	none	.....	fair	fair	good	fair	fair
King	.....	.....	.....	good	little	KE	.....	fair	fair	good	fair	fair
Gravenstein	.....	.....	.....	fair	fair	KE	heavy	fair	fair	good	fair	little
Clayton	.....	.....	.....	.....	.....	KE	.....	good	little	.....	.....	.....
Jefferis	.....	.....	.....	good	little	KE	.....	good	little	good	fair	bad
Jefferis	.....	.....	.....	.....	.....	KE	.....	good	little	dead	.....	.....

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Cogswell	fair	much	small			RS				dead		
Cogswell	fair	much	small			RS				good	little	fair
Edward's Sweet						RS						
Autumn Bough						RS				good	little	fair
Australian						RS		good	little			
Duchess of Oldenburg	small	bad	good			RS				good	fair	little
Rhode Island Greening	strong	little	heavy	good	little	ALSS	heavy	good	little	good	little	fair
Smokehouse*	strong	little	good	good	fair	none	fair	good	fair	dead		
Smokehouse*	strong	little	good	good	fair	none	fair	fair	fair	good	fair	bad
Autumn Strawberry	fair	much	fair	good	small	none		small	little	dead		
Dickinson				fair	little	none		fair	little			
Morton's Pearmain				good	little	LSS		fair	little			
Lowell	fair		small	fair	little	LSS	fair	fair	fair	good	fair	fair
Porter	fair	little	fair	good	fair	none	good	good	fair	good	fair	fair
St. Lawrence				good	little	none		none	fair	good	fair	fair
Violet						none						
Dahlonega*	fair		good	fair	little	ACC		fair	little	good	fair	little
Dahlonega*	fair		good			ACC		good	fair	dead		
Carolina Red June	fair		small	fair	little	none	fair	fair	little	good	fair	little
Red Fall Pippin*	fair	little	good	good	little	none		good	little	good	fair	fair
Red Fall Pippin*	fair	little	good	good	fair	none		good	fair	dead		
Munson Sweet*						none				dead		
Munson Sweet*				fair	fair	KE		fair	fair	good	fair	fair
Buckingham				good	fair	KE		good	fair	good	fair	fair
Mammoth Black				good	little	KE		good	little			
Yopp's Favorite*	fair	much	fair			none		good	little	dead		
Yopp's Favorite*	fair	much	fair	good	little	RS		good	fair	good	fair	little
Sherwood's Favorite*	good		fair			none				dead		
Sherwood's Favorite*	good		fair	good	little	RS		little	fair	good	little	fair
Alexander*						none	good			good	fair	fair
Alexander*						RS	good			good	fair	fair
Fall Jenneting*						none				good	fair	fair
Fall Jenneting*						RS				dead		
Hall	small	bad	fair	fair	fair	ALSS	good	fair	fair	good	fair	little
Hall	small	bad	fair			none	fair			dead		
Hawthornden	fair	much	good			none	fair	good	little	good	fair	little
Mangum	fair	much	small	fair	little	none				good	fair	fair
Huntsman				fair	little	none		good	fair			
Pumpkin Sweet*	strong	much	small	good	fair	none	good	none	fair	dead		
Pumpkin Sweet*	strong	much	small	good	fair	none	good	fair	bad	good	little	little
Jersey Sweet*	fair	bad	fair	good	much	none	fair	small	much	dead		
Jersey Sweet*	fair	bad	fair	fair	fair	none		fair	fair	dead		
Pomme Royal*	fair	little	small	good	little	none		good	little	good	little	fair
Pomme Royal*	fair	little	small	fair	fair	ACC		fair	fair	dead		
Fall Wine*	good	much	small	good	fair	ACC		little	fair	good	fair	fair

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TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH APPLES—Continued.

Name.	Record Before 1892.			Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.		Woolly Aphis. 1894.
	Growth.	Woolly Aphis.	Yield.	Growth.	Oyster-Shell Scale.			Growth.	Oyster-Shell Scale.	Growth.	Oyster-Shell Scale.	
Fall Wine*	good	much	small	good	fair	none	.....	good	fair	dead	.....	.....
Disharoon*	strong	none	small	fair	little	BM	.....	fair	little	dead	.....	.....
Disharoon*	strong	none	small	fair	fair	none	.....	good	fair	good	little	little
Early Joe*	.....	.....	.....	good	little	none	.....	none	fair	good	fair	fair
Early Joe*	.....	.....	.....	fair	little	KE	.....	fair	little	dead	.....	.....
Early Harvest	strong	much	small	good	fair	KE	fair	good	fair	good	fair	fair
Golden Sweet	strong	little	good	fair	fair	KE	.....	little	fair	dead	.....	.....
Skinner's Seedling	strong	much	fair	.....	.....	RS	heavy	.....	.....	good	fair	little
Red Astrachan	fair	much	good	.....	.....	RS	good	.....	.....	good	fair	little
Benoni	.....	.....	.....	.....	.....	RS	.....	.....	.....	good	fair	fair
Hoover	.....	.....	.....	.....	.....	RS	few	.....	.....	good	little	fair
Primate	fair	.....	small	.....	.....	RS	fair	.....	.....	dead	.....	.....
Primate	fair	.....	small	.....	.....	RS	fair	.....	.....	good	fair	little
Summer Bellflower*	.....	.....	.....	.....	.....	none	fair	.....	.....	dead	.....	.....
Summer Bellflower*	.....	.....	.....	.....	.....	RS	fair	.....	.....	dead	.....	.....
Summer Rose	small	much	heavy	.....	.....	none	.....	.....	.....	dead	.....	.....
Summer Rose	small	much	heavy	.....	.....	none	.....	.....	.....	dead	.....	.....
McCloud's Family*	.....	.....	.....	.....	.....	none	good	.....	.....	good	fair	little
McCloud's Family*	.....	.....	.....	.....	.....	none	fair	.....	.....	dead	.....	.....
Julian*	.....	.....	.....	.....	.....	none	heavy	.....	.....	good	fair	fair
Julian*	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Summer Queen*	small	much	heavy	good	little	none	fair	fair	little	good	fair	fair
Summer Queen*	small	much	heavy	good	little	ALSS	fair	good	little	dead	.....	.....
Keswick Codlin	fair	bad	heavy	good	fair	ALSS	good	good	fair	good	fair	bad
Keswick Codlin	fair	bad	heavy	good	little	none	good	none	much	dead	.....	.....
Ingram	.....	.....	.....	fair	little	none	.....	good	little	.....	.....	.....
Charlottenthaler †	.....	.....	.....	fair	little	none	.....	fair	little	.....	.....	.....
Summer Hagloe*	fair	much	good	fair	little	none	.....	fair	little	good	fair	bad
Summer Hagloe*	fair	much	good	fair	fair	none	.....	none	fair	good	fair	bad
Sweet June	small	much	fair	fair	little	none	.....	none	fair	good	fair	fair
Clyman's Pippin	.....	.....	.....	fair	little	none	.....	none	fair	good	little	fair
Garretson's Early	small	much	small	good	little	none	fair	fair	little	good	fair	fair
Arkansas Black	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Seedless	.....	.....	.....	fair	fair	none	.....	fair	fair	dead	.....	.....
Kirkbridge White	small	much	good	fair	fair	none	.....	fair	fair	good	little	fair
Kirkbridge White	small	much	good	small	fair	none	.....	none	fair	good	little	fair

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Calville Rouge d'Eté				fair	fair	ABM		small	little	good	fair	fair
Calville Rouge d'Eté	small		small	fair	fair	ABM		fair	little	good	fair	fair
Calville Rouge d'Eté	small		small	fair	little	ABM		good	little	good	fair	fair

*Indicates selected trees. † Young trees.

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
Forelle			good	fair	ABM	good	good	bad	good	little
Vicar of Winkfield	strong	good	good	little	ABM	heavy	small	fair	dead	
Beurré Easter			good	fair	ABM	good	small	fair	fair	little
Pound			good	little	ABM	small	poor	little	dead	
Glout Morçeau			good	fair	none	good	poor	fair	good	little
Winter Nelis	fair	small	good	fair	none	poor	poor	fair	fair	little
Doyenne d'Alençon	good	fair	good	fair	none	good	fair	fair	good	little
Bezi Sanspareil*			good	little	none	good	poor	fair	dead	
Bezi Sanspareil*			good	little	none	good	poor	fair	good	little
Passe Colmar*	fair	small	good	little	none		small	little	dead	
Passe Colmar*	fair	small	good	little	none		small	fair	good	little
Pater Noster*			good	little	none	good	small	fair	dead	
Pater Noster*			good	little	none	good	poor	fair	good	little
St. André*			good	little	none	small	fair	fair	good	little
St. André*			good	little	none	small	poor	much	dead	
Marie Louise d'Uccles*	small	good	good	little	none	good	good	little	good	little
Marie Louise d'Uccles*	small	good			IS	good			good	little
Inconnue von Mons*	fair	good	good	little	none	good	fair	fair	good	little
Inconnue von Mons*	fair	good	good	little	IS	good	small	fair	good	little
Fondante de Noël*	fair	good	good	little	none	good	small	much	good	little
Fondante de Noël*	fair	good	good	little	none	good	small	fair	good	little
Epine Dumas*	poor	good	good	fair	none	large	small	fair	good	little
Epine Dumas*	poor	good	good	little	none	small	small	fair	good	little
Belle Williams*	good	small	fair	little	BM	none	good	little	good	little
Belle Williams*	good	small	good	little	none	none	good	fair	good	little
Bergamotte Cadet*	good	fair	good	little	none		fair	little	good	little
Bergamotte Cadet*	good	fair	fair	fair	none		good	little	good	little

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TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS—Continued.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
St. Germain*	good	heavy	good	little	none	small	small	fair	good	little
St. Germain*	good	heavy	good	little	LSS	small	small	fair	good	little
Beurré d'Aremberg*	good	good	fair	little	none	small	small	fair	fair	little
Beurré d'Aremberg*	good	good	fair	fair	LSS	small	fair	fair	dead	.....
Beaupresent d'Artois*	small	good	fair	fair	none	good	fair	fair	good	little
Beaupresent d'Artois*	small	good	fair	little	LSS	good	fair	fair	dead	.....
Beurré Précoce	small	good	fair	little	ALSS	none	small	fair	dead	.....
Beurré Précoce	small	good	good	little	none	good	small	little	fair	little
Calabasse Monstreuse	poor	good	good	little	ALSS	.....	fair	fair	fair	little
Calabasse Monstreuse	poor	good	fair	little	none	.....	poor	fair	dead	.....
Doyenne Sieulle*	fair	good	good	little	ABM	.....	little	fair	good	little
Doyenne Sieulle*	fair	good	good	little	ABM	.....	little	fair	good	little
Chaptal*	.....	.....	good	little	ABM	.....	small	little	fair	little
Chaptal*	.....	.....	fair	little	none	good	poor	fair	dead	.....
Bonne Sophie	poor	fair	.....	.....	none	.....	dead	.....	dead	.....
Bonne Sophie	poor	fair	fair	little	none	.....	poor	little	fair	little
Moyamesing*	strong	small	fair	little	none	good	good	little	good	little
Moyamesing*	strong	small	fair	little	none	good	small	fair	good	little
Idaho†	.....	.....	.....	.....	none	.....	poor	fair	dead	.....
Figue d'Alençon	fair	fair	good	little	none	poor	small	fair	good	little
Washington*	.....	.....	good	little	none	good	.....	.....	good	little
Washington*	.....	.....	.....	.....	none	good	.....	.....	good	little
Star of Bethlehem*	.....	.....	good	little	none	.....	fair	fair	dead	.....
Star of Bethlehem*	.....	.....	good	little	none	.....	small	fair	dead	.....
Prince St. Germain	small	small	good	little	none	good	small	fair	good	little
Prince St. Germain	small	small	good	little	none	none	small	fair	good	little
Chaumontel	.....	.....	good	little	IS	good	fair	fair	good	little
Manning's Elizabeth*	.....	.....	small	little	none	good	fair	little	good	little
Manning's Elizabeth*	.....	.....	fair	little	IS	good	poor	fair	good	little
America*	strong	small	good	fair	none	.....	fair	fair	dead	.....
America*	strong	small	good	little	IS	.....	fair	little	good	little
Josephine de Malines	fair	small	good	little	none	.....	fair	little	good	little
Josephine de Malines	fair	small	good	little	none	.....	good	little	good	little
Augustus Dana*	strong	small	good	little	none	small	good	little	good	little
Augustus Dana*	strong	small	good	little	none	small	small	little	good	little
Beurré Gris d'Hiver Nouveau*	fair	good	.....	.....	IM	good	small	fair	good	little

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Beurré Gris d'Hiver Nouveau*	fair	good	fair	little	none	good	fair	little	good	little
Lawrence*	strong	fair	fair	little	BM	heavy	fair	little	good	little
Lawrence*	strong	fair	good	little	none	heavy	good	little	good	little
Doyenne d'Alençon*	good	fair	good	little	LSS	heavy	good	little	good	little
Doyenne d'Alençon*	good	fair	good	little	none	heavy	good	fair	good	little
Bergamotte d'Esperen*	fair	good	good	little	LSS	poor	fair	fair	good	little
Bergamotte d'Esperen*	fair	good	good	little	none	poor	poor	fair	good	little
Columbia*	------	------	fair	little	none	few	small	fair	good	little
Columbia*	------	------	good	little	none	none	poor	fair	good	little
Jaminette	fair	good	good	little	ABM	------	fair	fair	dead	------
Jaminette	fair	good	good	little	none	------	fair	fair	good	little
Rutter*	strong	heavy	good	little	ABM	good	good	little	dead	------
Rutter*	strong	heavy	good	little	none	good	fair	little	good	little
Dr. Reeder*	small	fair	good	little	ABM	good	fair	little	good	little
Dr. Reeder*	small	fair	good	little	ABM	good	small	fair	dead	------
Duchesse de Mouchy†	small	good	good	little	none	------	good	little	dead	------
Duchesse de Mouchy	small	good	good	little	none	good	fair	fair	good	little
André Desportes	fair	fair	good	little	none	good	poor	bad	dead	------
Court Queen	fair	fair	good	little	none	good	poor	fair	good	little
Court Queen	fair	fair	good	little	none	good	small	fair	good	little
Anne Orgereau	fair	fair	good	little	none	good	poor	fair	good	little
Madame Cuissard*	------	------	good	little	none	good	fair	little	good	little
Madame Cuissard*	------	------	good	little	KE	good	fair	fair	dead	------
Mount Vernon*	fair	small	good	little	none	heavy	fair	fair	dead	------
Mount Vernon*	fair	small	fair	little	KE	heavy	poor	fair	good	little
Levard	------	------	fair	little	none	------	small	fair	dead	------
Levard	------	------	good	little	none	good	small	fair	good	little
Napoleon the Third*	strong	good	good	little	none	good	good	little	good	little
Napoleon the Third*	strong	good	good	little	RS	good	small	little	good	little
Beurré Assomption	fair	good	good	little	IS	good	poor	fair	good	little
Beurré Assomption	fair	good	fair	fair	IS	good	poor	fair	dead	------
Louis Vilmorin	small	fair	good	little	IS	none	small	little	good	little
Louis Vilmorin	small	fair	good	little	none	good	poor	fair	dead	------
Eugene Appert*	fair	small	good	fair	none	good	good	little	good	little
Eugene Appert*	fair	small	fair	little	CS	good	good	little	good	little
Brockworth Park*	fair	heavy	good	little	none	heavy	good	little	good	little
Brockworth Park*	fair	heavy	good	little	none	heavy	small	little	good	little
St. Crispin*	------	------	------	------	BM	good	small	fair	good	little
St. Crispin*	------	------	good	little	none	good	small	little	dead	------
Petite Marguerite*	good	good	good	little	none	heavy	good	fair	good	little
Petite Marguerite*	good	good	good	little	none	heavy	fair	little	dead	------
Maréchal Vaillant*	good	small	fair	little	none	good	small	fair	dead	------
Maréchal Vaillant*	good	small	fair	little	LSS	good	small	fair	good	little
Duchesse Précoce	fair	good	fair	fair	LSS	small	small	fair	dead	------
Duchesse Précoce	fair	good	fair	little	none	none	small	fair	fair	little

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TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS—Continued.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
Duchesse of Bordeaux*	poor	good	good	little	ALSS	none	small	little	fair	little
Duchesse of Bordeaux*	poor	good	fair	little	ALSS	good	small	fair	good	little
Souvenir du Congrès*	good	fair	fair	little	ALSS	heavy	fair	fair	good	little
Souvenir du Congrès*	good	fair	good	little	none	heavy	small	little	good	little
Duhamel du Monceau	poor	good	good	little	ABM	heavy	poor	fair	fair	little
Duhamel du Monceau	poor	good	good	little	ABM	heavy	poor	fair	dead	.....
Pitmaston's Duchesse*	strong	small	good	little	ABM	good	good	fair	good	little
Pitmaston's Duchesse*	strong	small	good	fair	none	good	good	fair	good	little
Madame Treyve	small	good	fair	little	none	.....	poor	fair	dead	.....
Madame Treyve	small	good	fair	fair	none	.....	fair	fair	good	little
Sarah*	.....	.....	fair	little	none	good	good	fair	good	little
Sarah*	.....	.....	fair	fair	none	good	small	fair	good	little
Bonne du Puits Ansault	poor	fair	.....	.....	none	.....	dead	.....	dead	.....
Bonne du Puits Ansault	poor	fair	fair	little	KE	.....	poor	fair	good	little
Madame Loriol de Barney	fair	good	fair	fair	none	good	small	fair	good	little
Madame Loriol de Barney	fair	good	fair	fair	KE	.....	poor	much	dead	.....
Williams' d'Hiver*	.....	.....	good	little	none	light	small	fair	good	little
Williams' d'Hiver*	.....	.....	fair	little	KE	light	.....	.....	dead	.....
Maurice Desportes	small	small	fair	little	RS	none	good	little	good	little
Maurice Desportes	small	small	.....	.....	none	.....	dead	.....	dead	.....
Beurré Clairgeau	fair	fair	fair	little	none	none	small	fair	small	little
Beurré Sterkmans	.....	.....	good	fair	RS	good	fair	fair	good	little
Duchesse	small	small	good	fair	IS	light	poor	much	good	little
Seckel	fair	fair	good	fair	IS	good	fair	fair	good	little
Beurré d'Anjou	fair	fair	good	little	IS	heavy	little	fair	small	little
Andrews	small	good	good	fair	IS	good	small	much	small	little
Ananas d'Eté*	fair	poor	good	little	none	good	good	little	good	little
Ananas d'Eté*	fair	poor	fair	little	CS	good	little	little	good	little
St. Michael Archange*	fair	good	good	little	ACC	good	little	fair	fair	little
St. Michael Archange*	fair	good	good	much	none	good	small	much	fair	little
Rouselet Stuttgart	.....	.....	good	little	none	heavy	small	little	fair	little
Rouselet Stuttgart	.....	.....	good	little	none	heavy	small	little	dead	.....
Jaloise de Fontenay Vendée*	fair	good	good	little	none	good	small	fair	good	little
Jaloise de Fontenay Vendée*	fair	good	good	little	none	good	small	fair	good	little
De Tongres*	good	good	good	fair	none	heavy	good	fair	good	little
De Tongres*	good	good	good	little	none	heavy	small	fair	dead	.....

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Henry the Fourth	fair	good	fair	little	none	good	poor	fair	dead	------
Nantals*	fair	good	------	------	none	good	------	fair	little	
Nantals*	fair	good	good	little	ALSS	good	fair	little	good	little
Nouveau Poiteau	good	------	good	little	ALSS	good	fair	little	small	little
Nouveau Poiteau	good	------	fair	little	ALSS	good	small	little	small	little
Vicar of Winkfield*	strong	good	good	little	none	good	small	fair	fair	little
Vicar of Winkfield*	strong	good	good	little	ALSS	good	fair	little	fair	little
Beurré Goubalt*	heavy	heavy	good	little	none	heavy	small	little	good	little
Beurré Goubalt*	heavy	heavy	fair	fair	none	heavy	good	bad	good	little
Bonne d'Ezée*	fair	heavy	fair	fair	none	good	small	fair	good	little
Bonne d'Ezée*	fair	heavy	good	fair	none	good	fair	fair	good	little
Beurré Golden of Bilboa*	------	------	fair	little	none	heavy	good	fair	good	little
Beurré Golden of Bilboa*	------	------	good	little	none	heavy	good	fair	good	little
Doyenne Robin	good	good	good	little	none	heavy	fair	little	dead	------
Doyenne Robin	good	good	good	little	none	heavy	small	little	good	little
Duchesse de Berry d'Eté	fair	small	good	little	KE	good	small	fair	dead	------
Duchesse de Berry d'Eté	fair	small	good	little	KE	good	little	fair	good	little
Gratiola de Jersey	good	good	fair	little	KE	good	fair	fair	fair	little
Gratiola de Jersey	good	good	fair	little	KE	good	------	------	dead	------
Liberale	fair	fair	------	little	none	light	fair	little	dead	------
Liberale	fair	fair	fair	little	RS	light	small	little	good	little
Duchesse d'Orleans*	strong	good	fair	little	none	none	small	fair	dead	------
Duchesse d'Orleans*	strong	good	good	little	none	good	fair	little	good	little
Flemish Beauty	fair	fair	------	------	IS	good	------	------	good	little
Admire Joannet*	------	------	good	little	none	heavy	good	little	dead	------
Admire Joannet*	------	------	good	little	CS	heavy	good	little	good	little
Baronne de Melo*	fair	good	fair	fair	none	good	good	little	good	little
Baronne de Mello*	fair	good	good	fair	CS	good	good	fair	good	little
Beurré Amande*	fair	good	good	little	none	none	fair	fair	------	------
Beurré Amande*	fair	good	fair	little	ACC	none	fair	fair	------	------
Kingsessing*	good	small	small	little	none	none	good	little	good	little
Kingsessing*	good	small	good	little	ACC	none	good	little	dead	------
Ott*	small	fair	good	little	none	good	fair	little	good	little
Ott*	small	fair	good	little	none	good	good	little	good	little
Pratt*	small	small	good	little	none	good	small	fair	good	little
Pratt*	small	small	good	little	SP	good	small	fair	good	little
Stephen's Genessee*	good	fair	small	little	none	------	small	little	good	little
Stephen's Genessee*	good	fair	fair	bad	SP	------	fair	bad	good	little
Kirtland*	------	------	good	little	none	heavy	small	fair	good	little
Kirtland*	------	------	good	little	none	heavy	good	little	good	little
Jones' Seedling	fair	good	------	------	none	heavy	------	------	small	little
Jones' Seedling	fair	good	good	little	ASP	light	small	fair	small	little
Canandaigua	fair	------	good	little	ASP	heavy	little	fair	fair	little
Canandaigua	fair	------	good	little	ASP	heavy	small	fair	fair	little

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TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS—Continued.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
Fulton	fair	fair	fair	fair	ASP	good	fair	fair	small	little
Fulton	fair	fair	good	little	none	light	small	fair	small	little
Dix	.....	.....	fair	little	none	none	small	fair	fair	little
Dix	.....	.....	fair	little	AACC	light	fair	fair	fair	little
Souvenir d'Esperen	.....	.....	good	little	AACC	light	small	fair	fair	little
Souvenir d'Esperen	.....	.....	.....	.....	AACC	none	good	fair	fair	little
Emile de Heyst	fair	good	fair	little	AACC	good	poor	fair	fair	little
Emile de Heyst	fair	good	fair	little	AACC	good	small	fair	dead	.....
Dana's Hovey	poor	small	fair	little	KE	poor	small	fair	dead	.....
Dana's Hovey	poor	small	small	little	KE	good	small	fair	good	little
Doyenne du Comice	fair	small	good	fair	KE	none	small	fair	fair	little
Doyenne du Comice	fair	small	good	much	KE	good	poor	much	fair	little
Beurré Langlier	strong	fair	good	little	RS	good	fair	fair	good	little
Beurré Langlier	strong	fair	small	little	RS	light	small	fair	dead	.....
Oswego Buerré*	good	fair	fair	little	none	none	small	fair	good	little
Oswego Buerré*	good	fair	good	little	RS	light	poor	fair	good	little
Doyenne White	fair	good	fair	fair	IS	heavy	good	fair	good	little
Doyenne White	fair	good	fair	little	CS	heavy	small	fair	dead	.....
Conseiller de la Cour*	heavy	good	good	little	none	heavy	fair	fair	good	little
Conseiller de la Cour*	heavy	good	little	fair	CS	heavy	small	fair	good	little
Urbaniste*	good	fair	good	little	none	none	fair	fair	good	little
Urbaniste*	good	fair	fair	fair	ACC	light	small	fair	good	little
Paradise d'Automne*	good	good	good	little	none	none	fair	fair	good	little
Paradise d'Automne*	good	good	good	fair	ACC	good	good	fair	good	little
Beurré Hardy*	good	fair	good	fair	none	light	small	fair	fair	little
Beurré Hardy*	good	fair	good	little	none	none	small	little	fair	little
Sheldon	fair	good	good	little	none	none	dead	.....	.....	.....
Sheldon	fair	good	good	little	SP	light	good	little	good	little
Howell*	good	good	good	fair	none	good	small	little	dead	.....
Howell*	good	good	good	little	SP	good	good	fair	good	little
Napoleon*	.....	.....	good	fair	none	light	fair	fair	dead	little
Napoleon*	.....	.....	good	little	none	light	small	fair	good	little
Beurré Bosc	strong	small	good	little	ASP	good	fair	little	good	little
Swan's Orange*	fair	good	.....	.....	none	good	.....	.....	fair	little
Swan's Orange*	fair	good	.....	.....	ASP	good	.....	.....	fair	little
Beurré Diel*	fair	fair	.....	.....	none	good	.....	.....	fair	little

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Louis Bonne de Jersey*	fair	fair			ASP	light			fair	little
Louis Bonne de Jersey*	fair	good	good	fair	none	good	small	fair	good	little
Paul Ambre*	fair	good			none	good	small	fair	good	little
Paul Ambre*			good	little	none	none	small	little	small	little
Buffum*			good	fair	AACC	light	small	little	small	little
Buffum*	fair	good	fair	fair	none	light	small	fair	small	fair
Beurré Superfin	fair	good	fair	little	AACC	good	poor	bad	small	fair
Beurré Superfin	fair	small	good	little	AACC	light	fair	fair	fair	little
Doyenne Boussock*	strong	good	good	little	KE	none	small	fair	fair	little
Doyenne Boussock*	strong	good	good	little	KE	heavy	small	fair	good	little
Gray Doyenne			fair	little	RS	heavy	fair	fair	good	little
Gray Doyenne			fair	little	RS	none	small	fair	dead	
Beurré de Waterloo*	fair	fair	good	little	none	none	small	little	small	little
Beurré de Waterloo*	fair	fair	good	little	RS	good	fair	little	fair	little
Madeleine	strong	small	good	little	CS	good	fair	fair	fair	little
Beurré Giffard	good	fair	good	little	CS	good	fair	fair	good	little
Dearborn's Seedling	strong	fair	good	little	CS	good	good	little	good	little
Osband's Summer			good	little	none	good	fair	little	good	little
Osband's Summer*			good	little	ACC	good	fair	fair	good	little
Belle Lucrative*	strong	good	good	little	none	heavy	fair	fair	good	little
Belle Lucrative*	strong	good	good	little	ACC	heavy	small	fair	good	little
Rostiezer*	good	small	good	little	none	good	poor	little	good	little
Rostiezer*	good	small	good	little	SP	good	good	little	good	little
Bartlett*	good	fair	fair	little	none	good	fair	little	good	little
Bartlett*	good	fair	good	little	none	good	fair	little	good	little
Tyson*			good	little	none	good	good	little	good	little
Tyson*			good	little	SP		good	little	good	little
Brandywine	good	good	good	little	none	good	good	little	good	little
Doyenne d'Eté*	small	fair			none	good			good	little
Doyenne d'Eté*	small	fair			ASP	none			dead	
Clapp's Favorite*	good	good			none	good			good	little
Clapp's Favorite*	good	good			ASP	good			good	little
Edmonds*	strong	heavy			none	none			dead	
Edmonds*	strong	heavy			ASP	none			dead	
Bloodgood*	good	good	good	little	none	good	small	fair	small	little
Bloodgood*	good	good	good	little	none	good	small	fair	dead	
P. Barry			fair	little	KE				small	little
Le Conte					KE				good	little
Keiffer					RS				good	little
Keiffer					RS				good	little

*Indicates selected trees. †Small trees.

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The treatments were made in the spring of 1892, just before the buds began to open, as indicated on the plot. In the spring of 1893 all the orchard was treated with resin soap, and this spring no treatment at all was made.

No results from the wash could be noted in the trees in the summer of 1892. Not that there was no difference between the various trees, but attempts to pick out trees that were washed and those not washed were as often wrong as right. It was hoped, however, that by taking a number of items and large averages some results could be obtained, so the above tables were prepared. The record before 1892 and the yield of 1892 are compiled from the notes of the Station foreman; the other columns are from my own observations.

The season of 1891, as shown by the growth observed in the spring of 1892, was good, but the year following the application was by no means as satisfactory, though the yield was very fair. Last year was very good, and this year promises to be also very good. The variation in the abundance of scale insects seems to follow the growth in inverse order, and this, broadly speaking, seems to be true of insect attack in general.

The pears were all more or less affected with the greedy scale, *Aspidiotus rapax*, which is very abundant on a great variety of trees on the University grounds, and all over town. They occur in small numbers on all kinds of fruit trees, including the olive and citrus trees, as well as the deciduous fruit, but are very abundant only on the pears, and one or two varieties of apples and cherries. On the California bay laurels along the creek, quite near the orchard, this scale was very abundant about the time these experiments were begun, but have now almost all disappeared, apparently the result of a disease. In the Economic Garden, below the orchard, the scale was very abundant on quite a number of exotic trees, and they have similarly decreased, but accompanied in this instance by a great increase in numbers of the twice-stabbed ladybird. In the town a decrease of the scale, though not quite so well marked, clearly results from the work of the English sparrow. The ladybirds and sparrows have not been unusually abundant in the orchard, and the disease seems to have been the chief natural check.

The oyster-shell scale was very abundant on a number of the apples, and present in some numbers on all, and on a very few pears, but apparently on no other trees. The same or a similar disease to that attacking the *A. rapax* was noticed, but no other natural enemies.

The only other insects very abundant in the orchard were the woolly aphis and the codlin moth. These have been treated of to some extent in the last two reports. Further data is given above in regard to the former.

In the tables above, the terms small, fair, and good are used as being more intelligible than figures, but for comparison it becomes necessary to use numbers, so that they may be added and the averages obtained. In the tables below the following values are given to the words used in the first tables:

1 = none, poor, few. 3 = fair.
2 = small, little, light. 4 = large, much, good.
5 = strong, heavy, bad.

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Table showing the Yield of the Apples and Pears.

Treatment.	Apples.				Pears.			
	Before 1892.		Summer of 1892.		Before 1892.		Summer of 1892.	
	No. of Trees.	Yield.	No. of Trees.	Yield.	No. of Trees.	Yield.	No. of Trees.	Yield.
Resin soap	11	2.6	8	3.1	7	3.0	10	2.5
do arseniated	1	2.0	2	3.5	.....	.....	.....	.....
Ammoniacal copper carbonate	8	3.0	2	3.5	6	3.5	7	3.0
do arseniated	3	3.7	2	3.5	4	3.5	8	2.6
Sulphid of potash	.....	.....	.....	.....	5	3.0	4	3.5
do arseniated	.....	.....	.....	.....	8	3.5	10	3.2
Copper sulphate	.....	.....	.....	.....	8	3.0	9	4.3
Kerosene emulsion	5	3.0	6	3.5	14	2.8	14	3.4
Bordeaux mixture	2	2.0	.....	.....	3	3.0	4	3.5
do arseniated	5	2.2	3	3.7	10	3.7	10	4.1
Lime, salt, and sulphur	14	2.8	9	3.5	7	3.7	7	2.9
do arseniated	4	4.5	4	4.0	7	3.9	8	3.4
Iron sulphate	.....	.....	.....	.....	12	3.3	12	4.0
Untreated	50	3.1	37	3.5	112	3.4	126	3.5

Table showing the Growth of the Apple Trees.

Treatment.	Before 1892.		Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.
Resin soap	11	3.2	2	4.0	3	3.3	13	4.0
do arseniated	1	3.0	4	4.0	4	4.0	2	4.0
Ammoniacal copper carbonate	8	2.9	12	3.8	12	3.8	6	4.0
do arseniated	3	4.3	5	4.0	6	3.5	3	4.0
Kerosene emulsion	5	4.3	18	3.4	21	3.2	12	4.0
Bordeaux mixture	2	5.0	5	3.4	5	3.4	1	4.0
do arseniated	5	2.2	8	3.6	8	3.6	6	4.0
Lime, salt, and sulphur	14	3.6	19	3.8	22	3.6	18	4.0
do arseniated	4	2.3	4	3.8	4	3.8	3	4.0
Untreated	50	3.3	67	3.6	74	3.3	51	4.0

Table showing the Growth of the Pear Trees.

Treatment.	Before 1892.		Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.
Resin soap	7	2.9	10	3.4	10	2.4	10	3.7
Ammoniacal copper carbonate	6	3.8	7	3.7	7	2.9	5	3.8
do arseniated	4	3.0	7	3.4	8	2.3	7	2.7
Sulphid of potash	5	3.4	6	3.8	6	3.5	6	4.0
do arseniated	10	3.4	5	3.8	5	2.4	8	3.0
Copper sulphate	8	3.9	9	3.4	9	3.1	8	4.0
Kerosene emulsion	14	3.0	17	3.4	14	1.9	12	3.5
Bordeaux mixture	3	4.0	2	3.0	4	2.8	4	4.0
do arseniated	10	3.0	14	4.0	14	2.4	8	3.6
Lime, salt, and sulphur	7	3.5	7	3.4	7	2.7	4	4.0
do arseniated	9	2.8	9	3.6	9	2.6	8	3.1
Iron sulphate	12	2.6	12	3.8	12	2.1	13	3.8
Untreated	112	3.3	134	3.7	134	2.5	112	3.8

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Table showing the Abundance of the Oyster-shell Scale on the Apples.

Treatment.	Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Abundance.	No. of Trees.	Abundance.	No. of Trees.	Abundance.
Resin soap	2	2.0	3	2.7	13	2.7
do arseniated	4	2.5	4	2.8	2	3.0
Ammoniacal copper carbonate	12	2.8	12	3.0	6	3.0
do arseniated	5	2.6	6	2.5	3	2.0
Kerosene emulsion	18	2.7	21	2.9	12	2.9
Bordeaux mixture	5	2.2	5	2.4	1	2.0
do arseniated	8	2.5	8	2.1	6	2.7
Lime, salt, and sulphur	19	2.6	22	2.5	18	2.3
do arseniated	4	2.2	4	2.5	3	2.7
Untreated	67	2.5	74	2.8	51	2.6

Table showing the Abundance of the Greedy Scale on the Pears.

Treatment.	Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Abundance.	No. of Trees.	Abundance.	No. of Trees.	Abundance.
Resin soap	10	2.9	10	2.5	10	2.0
Ammoniacal copper carbonate	7	2.3	7	2.9	5	2.0
do arseniated	7	2.1	8	3.1	7	2.1
Sulphid of potash	6	2.5	6	2.8	6	2.0
do arseniated	5	2.2	5	2.8	8	2.0
Copper sulphate	9	2.2	9	2.4	8	2.0
Kerosene emulsion	17	2.2	14	3.1	12	2.0
Bordeaux mixture	2	2.0	4	2.5	4	2.0
do arseniated	14	2.4	14	2.9	8	2.0
Lime, salt, and sulphur	7	2.3	7	2.9	4	2.0
do arseniated	9	2.0	9	2.4	8	2.0
Iron sulphate	12	2.4	12	3.0	13	2.0
Untreated	134	2.1	134	2.7	122	1.8

Table showing the Abundance of the Woolly Aphis on the Apples.

Treatment.	Before 1892.		Summer of 1894.	
	Number of Trees.	Abundance.	Number of Trees.	Abundance.
Resin soap	6	4.2	13	2.8
do arseniated	1	5.0	2	3.0
Ammoniacal copper carbonate	6	2.7	6	2.7
do arseniated	3	2.0	3	2.0
Kerosene emulsion	5	3.0	12	2.9
Bordeaux mixture	2	2.5	1	3.0
do arseniated	3	3.7	6	2.5
Lime, salt, and sulphur	10	3.0	18	2.3
do arseniated	4	4.0	3	3.3
Untreated	43	3.6	51	2.8

In preparing the above tables the selected trees only were used, until it was seen that it made no material difference in the figures when all the trees were used, to give greater value to the averages. In every case the number of trees included in an average is given.

Yield after Treatment.—The yield gives the most tangible record of the results of the treatment. The season following the application

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shows a larger yield than the earlier record, and this increase is somewhat greater in the treated trees than in those untreated, but the difference is too slight to have any significance. Only with iron sulphate and copper sulphate is there a decided increase over the untreated trees. The results are sufficiently distinct with these, however, and probably represent the amount of reduction of the pear scab, which is quite prevalent all over the orchard. It is interesting to note that all of the other fungicidal washes excepting Bordeaux mixture showed, if anything, the opposite results on the pears, the two most used in this State: sulphid of potash, and lime, salt, and sulphur, making no better showing than the weak ammoniacal copper carbonate, which has never been recommended except for summer use.

Growth after Treatment.—The character of the growth is a very good index of the condition of a tree, and should therefore permit one to judge very accurately of the effect of a treatment. It will be noticed that the growth recorded in the spring of 1893, which represents that made the preceding summer, when the various washes would have their effects, if at all, shows in no case an increased growth over the preceding year, whereas the following season presents no case of decrease. This might suggest that the resin soap used in 1893 was very beneficial, were it not a fact that the trees treated with this wash in 1892 show about the greatest decrease in growth of all. The great variation in the first column is explainable on the ground that it is estimated upon a somewhat different basis from the other columns, and by a different person, and is therefore not so closely comparable. The apples treated with resin soap and arseniated ammoniacal copper carbonate decreased decidedly more in their yield than the others, and with Bordeaux mixture, both simple and arseniated ammoniacal copper carbonate and the arseniated resin soap and arseniated lime, salt, and sulphur, the growth was the same as the year before. A careful study of the whole table leaves one in doubt as to the significance of these facts. In the pear orchard the trees treated with sulphid of potash, Bordeaux mixture, and copper sulphate show decidedly less decrease in growth as compared with the others, but the two former lots are not large enough in number of trees to give much significance to this fact, especially since the arseniated treatments in neither of these cases show the same results. On the whole, it is evident that judging from the growth alone, the effects of the treatments were about nothing.

Scale Insects.—The destruction of scale insects is generally looked upon as the chief object of washing trees. The most evident fact brought out by the tables of scale-abundance is that neither for the oyster-shell scale nor for *Aspidiotus rapax* was any of the washes tried even fairly successful in killing the scale; and this result was not at all due to any lack of thoroughness of treatment. The simple fact is that none of these washes, as ordinarily applied, are able, under these conditions, to destroy these scales. In the apple orchard the trees treated with arseniated ammoniacal copper carbonate, lime, salt, and sulphur, and arseniated Bordeaux mixture showed a decrease in the abundance of the scale, and all the others an increase; while on the pears with the *Aspidiotus rapax* the resin soap was the only wash capable of producing any appreciable effect.

The woolly-aphis table is given to complete the *résumé* of the experi-

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ments, though the records were not taken near enough to the treatments to give much weight to the results.

A very slight abatement of pear scab where strong fungicides were used, and a still more slight decrease in the abundance of the scales in some cases, can be looked upon as the total appreciable results of the treatments. What the decrease in the abundance of the scales amounted to it is difficult to say, as neither the yield nor the character of the growth of the trees showed anything in these cases. There are no data available as yet showing even approximately the average amount of injury due to scale insects. A comparison of the relative abundance of the scales with the growth of the trees the following season should give a fair idea of the amount of this injury.

Relation of Scale to Tree Growth.—The following table compares the scale conditions in the springs of 1892 and 1893 with the growth observed in the springs of 1893 and 1894, respectively, of all the trees in which we have data:

Table showing the Relation of Scale Insects and Tree Growth.

Abundance of Scales.	Growth.					No. Dead.	Per cent Dead.
	Poor.	Small.	Fair.	Good.	Average.		
Pears.							
Little	26	85	58	87	2.8	13	5.0
Fair	5	22	31	101	3.4	27	14.5
Much	1	2	2	2	2.7	2	22.2
Bad		1	1	3	3.4	1	16.7
Apples.							
Little	7	2	27	74	3.5	21	15.9
Fair	4	5	16	90	3.7	31	20.8
Much		1	2	6	3.6	3	25.0
Bad				3	4.0	1	25.0

The above table gives the entirely unlooked-for result that on the more infested trees the growth is decidedly the best. The death-rate, however, is distinctly larger on the worst infested trees. These facts indicate that the scales exert no appreciable effect on healthy trees, but that on trees that are in a bad condition they do become very serious matters.

Practical Suggestions.—Two items, therefore, must be considered in the logical treatment of trees for scales: the maintenance of a vigorous condition of the tree, and the destruction of the scale; and if either of these measures is successful all injury from this source will be prevented. It is entirely possible for a tree to be in a satisfactorily healthy condition and still badly infested with scale insects. If one of these two items fails, especial attention must be given to the other. Thus in a dry season it becomes impossible to preserve the healthy condition of the tree, and then the destruction of the scale becomes an important matter. On the other hand, if a good season is at hand, of which we are often able to judge with a good degree of certainty, the spraying may be neglected with impunity and an opportunity given for the multiplication of the natural enemies of the scale, and these may be able to keep the scale in check for a number of years to come. This suggestion does not,

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of course, apply to those regions where it has become the policy to eradicate entirely certain scales.

The fact that neglected orchards though left to themselves become spontaneously clean after having been overrun by scales is proverbial, and has been observed by almost every one. This should not be looked upon as proving the general uselessness of washes, but it does speak eloquently of the folly of spraying by rote.

Misconceptions as to the action of insecticides often occur under such circumstances, and the wonderful testimonials for harmless and useless remedies by good, honest men are easily understood.

The importance of spraying, however, should not be underestimated. It is often the line dividing failure and success. What these experiments have proven, and what should be impressed, is that the common method of spraying once each winter is, under some circumstances, a valueless and wasteful procedure.

REMEDIES FOR PLANT DISEASES.

The following list of remedies for plant diseases was sent out as a special bulletin to meet the constant demand for information on the subject:

For POWDERY MILDEWS use *sulphur*, dusting it on the plants.

For FUNGI in general use *Bordeaux mixture*, made as follows: For every 10 gallons take 1 pound of lime and 1 pound of bluestone. Dissolve these separately in hot water and mix when cool, adding the rest of the water. Spray on the plants. Or spray with *ammoniacal copper carbonate solution*, made as follows: Dissolve 1 ounce of copper carbonate in 6 ounces of ammonia and add 10 gallons of water.

For FUNGI and SCALE INSECTS use *lime, salt, and sulphur mixture*, a **winter** wash composed of lime 8 pounds, salt 3 pounds, and sulphur 4 pounds, for each 12 gallons of water. Mix one fourth of the water, one fourth of the lime, and all the sulphur, and boil for one and a half hours; put the salt with the rest of the lime and slake with hot water; add to the above and boil half an hour longer; add the remainder of the water and apply as a spray.

For SCALE INSECTS use *resin soap*, as follows: For 100 gallons for **summer** use take resin 18 pounds, caustic soda (98 per cent) 3½ pounds, and fish oil 2½ pints; for **winter** use, resin 30 pounds, caustic soda 6¼ pounds, and fish oil 4½ pints. The material is put in a kettle and covered with four or five inches of water. The lid is put on and the mixture boiled two hours or more, and then the rest of the water is added, a little at a time. Spray on the plants. Or use the *gas treatment:* Cover the plant with an oiled tent, and for each 100 cubic feet of contents place in a bowl beneath the tent ⅔ ounce of water, ½ ounce of sulphuric acid (oil of vitriol), and ½ ounce of potassium cyanide (58 per cent), being careful not to inhale the poisonous gas nor to allow it to escape from the tent for half an hour. The leaves may be injured if used during the middle of the day.

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For INSECTS in general use *kerosene emulsion*, as follows: Make a soap solution of half a pound of soap to a gallon of water. Heat it to boiling and add two gallons of kerosene. Pump it through the spray pump, with good pressure, for five to ten minutes. For use add ten times as much water as you have of emulsion. Apply as a spray. Sour milk may be used instead of the soap solution. The emulsion is made more effective by the addition of a very small amount of arsenic to the soap solution, or of buhach to the kerosene.

For FRUIT OR LEAF-EATING INSECTS use *Paris green* or *London purple* as a powder at the rate of 1 to 5 pounds to the acre, distributed by walking or riding over the field, carrying a pole, at both ends of which are hung muslin bags containing the poison. As a spray use 1 pound to 200 gallons of water. In spraying these arsenites the nozzle should be held at some distance from the plant and *no more should be applied after the leaves begin to drip.* Do not use these on crops where the poison would be injurious to health.

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APPENDICES.

I. The Experiment Station Exhibit at the World's Fair in Chicago, and at the Midwinter Fair in San Francisco.

II. Fruit Tree Catalogue of varieties in the orchards of the Experiment Stations.

III. The Library and Reading-Room of the Station.

IV. Financial Statements.

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THE EXPERIMENT STATION EXHIBIT

AT THE

WORLD'S FAIR IN CHICAGO, AND MIDWINTER FAIR IN SAN FRANCISCO.

By R. H. Loughridge.

At the meeting of the Association of Agricultural Colleges and Experiment Stations held in 1891, a committee was appointed to formulate plans for and to take charge of an exhibit at the Columbian World's Fair in Chicago, which would in the best manner represent the work being carried on by the Agricultural Colleges and Stations throughout the United States. The committee divided the proposed exhibit into the appropriate groups, and special agents were placed in charge of the preparation of each.

Each College and Experiment Station was then called upon for something of its material for these divisions, so as to make the whole as national in character as possible. For the division of soils, Prof. E. W. Hilgard, Director of the University of California Stations, was placed in charge; the coöperation of each Station in the United States was asked to make the representation of the characteristic soils of each State as complete as possible.

As the space allotted to the soil-exhibit was very limited, it was found that only from ten to eighteen soils could be sent from each State, when taken in the manner desired. Each sample was to represent not the surface soil only, but a section to a depth of three feet, and to be in the form of a solid column of undisturbed earth, four inches wide and three inches thick. In this form could be seen all of the varying features to a depth of three feet, or that reached by the roots of most crops. These columns were to be placed in boxes with glass fronts, and labels giving locality, natural vegetation, and the crops to which best adapted. It was hoped that chemical and mechanical analyses would accompany each sample, but most of the stations were not able to have these made.

After these preliminaries were arranged, Professor Hilgard was granted a year's leave of absence from the University, and the writer was appointed special agent in his place, to complete arrangements for the exhibit. Many of the stations were for various reasons, chiefly financial, not able to send soil samples, so that, as finally presented, there were about 300 soils prepared and exhibited, from the following States:

Alabama	10	New York	20
California	16	North Carolina	15
Colorado	6	Oklahoma	5
Connecticut	15	Ohio	3
Florida	13	Oregon	11
Illinois	6	Rhode Island	8
Kentucky	16	Tennessee	15
Kansas	9	Texas	12
Massachusetts	13	Utah	4
Mississippi	18	Washington	16
Nebraska	8	Wyoming	7
Nevada	13		
New Mexico	10	Total	265

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THE CALIFORNIA EXHIBIT AT CHICAGO.

SOILS.

California, as one of the largest States, and having more varied climatic and agricultural regions, was entitled to sixteen samples of soils as representing the more important regions. The localities from which the soils were to be taken were chosen so as to be fairly characteristic of each region; and the duty of collecting the samples was placed in the hands of C. H. Shinn, the Inspector of Stations. The following general agricultural regions were selected: The Bay region; Santa Clara Valley; San Miguel Valley; Napa Valley; Sonoma Valley; Redwoods region; San Joaquin Valley; Sacramento Valley; Lower Sierra Foothills; San Bernardino Valley; ten regions in all, and from some of them two and even three samples, as representing that many varieties of soil, were chosen.

Analyses of each sample, both chemical and mechanical, were made, where not already on hand; the sediments obtained in the mechanical analysis placed in vials to accompany the respective soils; proper labels prepared showing locality where each soil was taken, the natural vegetation, the soil characteristics, and the crops to which best adapted.

The following comprise the soils and localities from which taken, and also the name of the collector. The analyses will be found either in previous reports of this Station or elsewhere in the present one:

Coast Region Soils.

NORTH OF THE BAY REGION: *Redwood Soil*, from the heavy forests on the land of Col. J. B. Armstrong near Guerneville, Sonoma County, and collected under his direction. It is coextensive with the redwood belt as shown on the map in Vol. 9, Report Tenth Census of the United States. The mechanical and chemical analyses of this soil are found elsewhere in this report. The land is but little cultivated because of the heavy cost of clearing. It is, however, a first-class soil, and highly productive when planted to grapes and deciduous fruits.

Sonoma Valley Vineyard Soil, from J. H. Drummond's vineyard, near Glen Ellen, Sonoma County. This is a brownish, rather clayey loam from the lower vineyard; without perceptible change of nature or tint to three feet, the substratum below that depth gradually becoming more reddish and lighter in texture beyond the depth of four feet. It has a natural timber growth of scattered white oaks. It is a fairly productive soil and first class for wine grapes and fruits, especially almonds and deciduous fruits. The sample was taken by C. H. Shinn; it represents a large area of hill and slope lands in Sonoma and Napa Counties. The analysis and description of similar soils are given in the Reports for 1883 and 1887.

Napa Valley Vineyard Soil, from the place of H. W. Crabb, 3 miles east of Rutherford, Napa County. The soil is a reddish-gray loam, containing considerable angular gravel, but silty rather than sandy; when dry the lumps crush readily between the fingers. The land originally had a natural growth of white oaks. The sample was taken by C. H. Shinn. The mechanical and chemical analyses of this soil appear elsewhere in this report. The sample represents fairly the majority of the fruit lands of the upper Napa Valley.

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THE BAY REGION: *Black Adobe Soil*, from the grounds of the University of California, Berkeley, Alameda County. A grayish-black clay soil, resembling the prairie soils of Illinois or Mississippi; evidently an ancient swamp deposit. It contains chiefly angular gravel of various rocks, mostly shales, that form the Coast Range at this point. When dry, the soil forms hard lumps, which do not yield to the fingers; on wetting it becomes very tenacious; in the dry season, when untilled, it opens into wide and deep suncracks. The natural growth is live oak, laurel, buckeye, buckthorn, etc. This is a first-class grain land, the climate not being adapted to commercial fruit culture. No irrigation is needed. The mechanical and chemical analyses are given elsewhere (No. 1679) in this report. This soil represents a highly productive belt of alluvial lands surrounding the bays of San Francisco and San Pablo.

SOUTH OF THE BAY REGION: *Santa Clara Valley Soil*, from the land of the Saratoga Prune Company on western valley slope, 4 miles west from San José, Santa Clara County. This is a drab-tinted loam, largely intermixed with gravel and rock fragments, which increase downwards; evidently washed from the Coast Range to westward. The tint becomes more yellowish toward three feet depth. The entire soil stratum is from 12 to 20 feet thick, and roots are naturally underdrained; and it tills easily, shortly after rains. The natural growth is chiefly herbaceous, with scattered white oaks. It is a first-class soil, yielding without irrigation, wine grapes, prunes, apricots, pears, cherries, figs, and small fruits. The sample was taken by C. H. Shinn. The mechanical and chemical analyses of a similar soil from Cupertino, No. 986, will be found in the Report for 1886. It represents the western slope of the Santa Clara Valley, occupied mainly by prune orchards and vineyards.

Mesa Soil from the Southern Coast Range Station, near Paso Robles, San Luis Obispo County. Yellowish drab in color, very loose and sandy, the sand consisting mostly of granite debris. The natural growth is Douglass' and white oak, with "openings" having a sparse growth of bunch grass and herbs. It represents the Estrella Plains of the upper Salinas River. The mechanical analysis of this soil, No. 1147, will be found in this report; the chemical analysis appeared in the Report for 1890.

Sediment Soil of the Valley of Santa Clara River, from the orchard of N. W. Blanchard, near Santa Paula, Ventura County. This is a silty soil, light in color, and easily tilled; of first quality, and produces citrus fruits, apricots, beans, and corn without irrigation. The sample was collected by C. H. Shinn. An analysis of a similar soil (No. 168) will be found in the Report for 1882. It represents the old alluvium or bench lands of that valley and of the Saticoy region.

Lower Sierra Foothills Region.

Granite Soil, from the Experiment Station near Jackson, Amador County. Its natural growth is pine and chaparral. It is much inferior to the red foothill soil, but produces deciduous fruits. It is much benefited by irrigation. Its chemical and mechanical analyses appear respectively in the Reports for 1890 and 1891. The sample was taken by Geo. Hansen, foreman of Station, and C. H. Shinn. It represents the lands

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of the granite areas which are interspersed among the "bedrock slates" of the western slope of the Sierra.

Red Foothill Soil (derived from the slate bedrock), from the Experiment Station near Jackson, Amador County. This is of first quality, having a natural growth of mountain oaks, and pines, buckeye, buckthorn, manzanita, madrone, chaparral, poison sumac, etc. It is much benefited by irrigation, and produces deciduous and citrus fruits, figs, and grapes. Its chemical and mechanical analyses appear respectively in the Reports for 1890 and 1891. The sample was collected by C. H. Shinn and Geo. Hansen. It represents the soils derived from the "bedrock slates" in which the placer mining of early times for gold was done.

Great Valley Region.

SACRAMENTO VALLEY: *Old Alluvium* or *"Middle-land" Soil*, from Putah Creek, near Dixon, Solano County. A mouse-colored clay loam, becoming quite plastic but not adhesive on wetting and kneading. Thickness from 12 to 20 feet to water. The natural growth is chiefly herbaceous, with scattered white oaks. The soil is first class in quality, producing table and wine grapes, apricots, prunes, pears, figs, and almonds. The sample was collected by C. H. Shinn. A chemical analysis of land of this character, No. 110, will be found in the Report for 1882. The mechanical analysis appears elsewhere in this report. It represents the alluvium of the western side of the Sacramento Valley.

Sacramento Valley Soil, from the place of R. C. Kells, 3 miles west of Yuba City, Sutter County. A loam of light-brownish tint, growing paler downward, varying in thickness from 8 to 12 feet, and then usually underlaid by gravel, therefore well drained. It is usually above overflow—characteristic of the Sacramento Valley between Feather River and the base of the foothills. The natural growth is chiefly herbaceous, with scattered white oaks. This is a first-class soil, producing citrus fruits, pears, prunes, apricots, and almonds, and mostly cultivated without irrigation. The sample was collected by Messrs. R. C. Kells and C. H. Shinn. The analysis, both mechanical and chemical, of the soil, No. 1645, appears elsewhere in this report.

SAN JOAQUIN VALLEY: *Reddish Sandy Soil*, from the ranch of C. C. Butler, near Fresno, Fresno County. A reddish-gray sandy loam, easily tilled at all times, varying somewhat in its degree of fineness and cohesiveness; easily irrigated and holding water well. It is from 8 to 25 feet in thickness and with little change; it represents the ancient alluvium of the upper San Joaquin River. Its natural growth is herbaceous. It is a first-class soil, requiring irrigation, and producing wine and raisin grapes, apricots, prunes, pears, alfalfa, figs, and almonds. A chemical analysis of this kind of land appears in the Report for 1890, while the mechanical analysis is presented in this. The sample was taken by C. H. Shinn.

Sandy Plains Soil, from the Experiment Station near Tulare. A yellowish-drab or fawn-colored, very sandy loam, easily tilled at all times: but little change to 12 feet. It has a natural growth of large white oaks, and is of good quality, but inferior to the "black lands" of the region. It is profusely productive under irrigation, and is well adapted to grain.

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alfalfa, deciduous fruits, and grapes. The sample was collected by Julius Forrer, the foreman of the Station. Its chemical analysis is given in the Report for 1889, and the mechanical analysis in that of 1891–92. It represents the ancient alluvium of the Kaweah River and its delta.

Black Lands Soil, or old swampy alluvium of Tulare Lake, Tulare County. A friable loam of dark mouse color, almost black when wet. It represents the ancient swamp deposits of the Tulare Lake border, and of its eastern affluents. Its depth is 8 to 12 feet, with but little change. It has no natural timber growth, and is of first quality, requiring but little irrigation, and producing grain, apricots, prunes, pears, etc. A chemical analysis of this variety of land, No. 1167, appears in the Report for 1882, and the mechanical analysis in that of 1891. The sample of soil was taken by Julius Forrer, foreman of the Station.

Southern California Region.

Reddish Bench, or Mesa Soil, from the site of the first orange grove in the town of Riverside. The natural growth is herbaceous only. This is the typical land of orange orchards; is first class in character, requires irrigation, and produces citrus fruits, grapes, and apricots. Its mechanical analysis appears elsewhere in this report. The sample was taken by Mr. J. E. Cutter.

Bench, or Mesa Soil, from the Experiment Station tract on Chino Ranch, San Bernardino County. A sandy loam of light cinnamon tint; an ancient valley alluvium. It is a first-class soil, with an herbaceous growth only. It requires irrigation, and produces citrus fruits, apricots, prunes, pears, and figs. Its chemical analysis appears in the Report for 1890; the mechanical analysis is given elsewhere in the present report. The sample was collected by C. H. Shinn.

AGRICULTURAL MAP OF CALIFORNIA.

For the past fifteen years this office has been accumulating data for the construction of a map which shall show as accurately as possible the close outlines of the many soil regions of the State. The information is not yet at all complete, and there are still large areas in which the lines marking distinct agricultural regions have not been closely defined. This is specially the case in the sparsely populated portions of the State, comprising the mountains and interior valleys. But still enough data have been collected to enable us to construct a map that gives very fairly the general soil regions, and some of the minor ones. Much assistance was rendered by the United States Topographical Corps, under Professor W. D. Johnson, in supplying contour outlines of mountain ranges and their valleys; also by several citizens of the State. Copies of a large base map of the State, 4 by 5 feet, were obtained through the courtesy of the State Mining Bureau, and upon this the regions selected for representation were outlined and defined by characteristic colors. The following regions were thus presented:

Great valley.
River and lake lands.
Tules.
Black adobe.
Black lands of Tulare.
Bedrock land of Sacramento Valley.
Red lands of Fresno and Tulare.

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Lower foothills region; from valley to 2,500 feet elevation.
Upper foothills; 2,500 to 3,500 feet elevation.
Granite lands.
Interior high valley and mesa lands.
Cultivable portion of Mojave Plateau. (Known or presumed to be cultivable, having a growth of yucca trees; irrigable from wells on west side of railroad; in eastern portion irrigable from Mojave River.)
Cultivable Coast Range. (Largely Tertiary and partly Cretaceous; mostly forming rounded ranges with sufficient soil for cultivation.)
Redwoods region.
High Coast Range. } Uncultivable land.
High Sierras. }
Lava beds. }
Desert. }

The whole map was then mounted and varnished and forwarded to the World's Fair, to be placed in the soil alcove. It was one of but few State soil maps there exhibited.

EXHIBIT OF MINERALS AND ROCKS TO ILLUSTRATE SOIL-FORMATION.

At the special request of Major Henry Alvord, Chairman of the committee, a small collection, intended to present the commonly occurring minerals and rocks which by disintegration go to form the greater part of all soils and clays, was made up in part from the Mineralogical Department of the University and in part from our own Station collection. It comprised about fifty mineral and rock specimens arranged and properly labeled.

APPARATUS FOR MECHANICAL SOIL ANALYSIS—"SOIL ELUTRIATOR."

This instrument, devised by Professor Hilgard many years ago for the separation of soil particles (clay, silts, and sands) into groups of different degrees of fineness, promises to supersede all others; and in order that it might attract the attention of those interested in soil investigations, it was decided to place one of the instruments in the Laboratory alcove and put it in running order. A handsome nickel-plated elutriator was therefore made under the direction of Mr. Sladky, Instructor in the College of Mechanics of this University, and forwarded to Chicago.

The instrument and its workings were fully described in the last report of this Station.

EXHIBIT OF APPARATUS CONSTRUCTED IN THE COLLEGE OF MECHANICS.

The exhibit from the College of Mechanics consisted of three pieces of apparatus. Two of these were small alternate-current dynamos of about two horse-power each, designed by the students in the department; one wound for a constant current, the other for a constant potential. The other instrument was a mechanical regulator for maintaining a constant difference of potential between the brushes of a dynamo, and was designed by Instructor J. N. Le Conte. These machines were constructed by the students in the workshops of the college.

CEREALS AND FORAGE PLANTS.

A large collection of cereals, grasses, and forage plants, fiber plants, etc., was made up from the growths on the grounds of the Central Station. In outline this exhibit was as follows:

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1. Cereals in sheaf, with threshed grain in bottles: Wheats, 129 varieties; spelts, 9 varieties; ryes, 7 varieties; oats, 39 varieties; barleys, 39 varieties.

2. Forage plants and grasses in bundles: Clovers, 13 species; grasses, 31 species; other forage plants, 19 species.

3. Fiber plants in bundles of stems: Flax, 8 varieties; ramie; esparto grass; New Zealand flax.

Each specimen was plainly labeled, and the collection as a whole very favorably commented upon.

THE MIDWINTER FAIR EXHIBIT.

The space allotted to the University of California occupied nearly the whole width of the north end of the Liberal Arts Building, and was divided into a number of alcoves, to each of which was assigned one or two of the departments of the University and the Professional Colleges. The whole presented a very fine and attractive exhibit of instruments, models, and material used in the class-room and museum.

One of these alcoves was occupied by the exhibit of the College of Agriculture and Experiment Stations; while another extensive wall space in the Horticultural Building was also used for a large exhibit of grain and fodder stuffs from the Station grounds. The necessarily limited space in the alcove precluded a very elaborate display from each of the branches of college and station work.

The specimens selected comprised the following:

SOILS.

The large samples. representing solid sections of soil from the surface to three feet in depth and four inches across, that had been boxed and sent to the World's Fair, were returned to us and again placed on exhibition in the alcove. They represented eighteen of the chief soil regions of the State, and are specially described in the preceding part of this report on exhibits. Another lot of specimens of soils in bottles was selected from the large collection of nearly 1,700 samples in the museum of the College of Agriculture. In this collection nearly every county in the State is represented to a greater or less degree, according to its rank as an agricultural region; thus some of the counties of the Great Valley have one or two hundred specimens each, while the Sierra mountain counties have but few samples.

From this collection about one hundred specimens were selected to represent as nearly as possible the varying soil features in each county, and were placed on shelves in the alcove.

AGRICULTURAL MAP OF THE STATE.

The large map on which had been outlined in different shades of color the chief agricultural regions of the State, and which had been sent to the World's Fair, was returned from Chicago in a somewhat mutilated condition, for it had been cut in two parts and tacked to the wall where exhibited. By remounting and varnishing, it was, however, made to present a fair appearance, and was placed in the Midwinter Fair exhibit.

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SOIL ELUTRIATOR.

The elutriator, an apparatus designed for the separation of the mechanical ingredients comprising a soil, which was sent to the Chicago Exposition, was received and placed in the alcove. A small dynamo from the College of Mechanics was connected with it to supply motive power. To illustrate the results obtained by it, there were arranged on either side, a series of vials containing the eleven sediments of clay, silt, and sand, of varying diameters, obtained from each of twenty soils.

SEED-TESTING APPARATUS.

Another addition to the exhibit was the set of apparatus recently received from Vienna by the Station for the purpose of testing the purity and vitality of commercial seeds. It comprised:

1. A miniature separator or fanning-mill to remove the chaff and other light material from the seed.
2. A series of seed sieves with apertures of different diameters, placed on an agitator or rocker to facilitate the removal of weed and other objectionable seed, and the separation of fine from coarse seeds.
3. A germinator in the form of a cabinet supplied with zinc pans for the sprouting of the seed, and arrangements for heating and the regulation of the temperatures.

PHOTOGRAPHS AND MAPS.

A large number of the photographic views of the grounds, buildings, and special cultures at the several experiment stations had been taken during the previous season, and from these groups a few were selected and framed for the exhibit.

The colored maps and sketches of the grounds of the Foothill Experiment Station, made by the foreman, George Hansen, were also added to the exhibit. They show the surface contours of the grounds and mark the areas devoted to the various experiments.

CEREALS AND FORAGE PLANTS.

The collection that had been sent to the World's Fair was duplicated with a new growth for the Midwinter Fair, and under the charge of Professor Wickson and Captain Kellner was made to present a very interesting and creditable appearance upon the wall of the Horticultural Building. The exhibit, as enumerated on a previous page, comprised 223 varieties of cereals, both in sheaf and threshed grain in bottles: 63 varieties of forage plants in bundles, and 8 varieties of fiber plants.

Specimens of the wheat and barley grown on alkali land reclaimed by gypsum (described and illustrated on page 147) were also exhibited.

OLIVES, OLIVE PITS, OLIVE OIL, AND GRAPE SEED.

This exhibit was prepared by Messrs. Hayne and Bioletti, and thus described by the former: From the oil-room were selected samples of oil made from the crop of 1893–94. These were selected to show first, the differences in the oil made from various varieties; second, the differences

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in the oil made from the same varieties grown on different soils and under different climatic conditions; third, the differences in the oil due to various processes in its preparation. The varieties thus tested were the Mission, Redding Picholine, Nevadillo Blanco, Rubra, Columbaro, Rock's Seedling No. 57, Oblonga, and frozen olives of several varieties mixed. In addition, there were over seventy samples of preserved olives, showing variety characteristics and local variations. These samples included the commoner California varieties and the best of the more recent foreign importations. With this last exhibit were a hundred and odd samples of olive pits from the collection used in the identification of doubtful varieties.

A model of a continuous, automatic, rapid-working oil separator recently invented in Italy was exhibited. This apparatus was of special interest, on account of the great saving of time and labor, as well as the lessening of the danger of rancidity that is as a rule attached to the present methods of oil manufacture.

The space allotted to the viticultural exhibit was so small that no wines or machinery could be taken from the wine cellar or viticultural laboratory, so the exhibit was, per force, confined to the above olive and olive oil samples, and grape seeds used in the identification of about fifty varieties.

ENTOMOLOGY.

The exhibit in entomology, under charge of Prof. C. W. Woodworth, "was designed to show especially the work of instruction in this department. It consisted of a desk of the form used in the entomological laboratory, and a set of wall cases, such as are used for specimens in the lecture-room. Upon the desk was shown the new orienting microscope, designed and built for our laboratory; a copy of the Laboratory Manual, used in the course in elementary and economic entomology; and a large jar illustrating the transformations of the honey bee. Upon the standard of the wall cases, a set of bottles illustrated the remedies recommended by us; and copies of the formulas were distributed during the fair. One of the wall cases represented the principal kinds of spraying nozzles; another, a dissection apparatus; ten were devoted to microscopical preparations of the anatomy of insects; and twelve boxes of beetles gave some idea of the collection of insects used in instruction in systematic and economic entomology."

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FRUIT TREE CATALOGUE.

LIST OF VARIETIES REPRESENTED JANUARY 1, 1894, IN THE ORCHARDS OF THE FIVE EXPERIMENT STATIONS.

The following list of varieties of fruits now growing at the Central Station, Berkeley, and at the sub-stations, does not include new varieties in the nurseries, nor those that have lately been top-worked on seedling trees in the orchards. If these were also listed, the catalogue would be much longer, but it has been the aim of the compiler to include only those varieties that we know to be true to name and well established in the orchards. We hope to issue a complete descriptive catalogue at some future time, with especial reference to Pacific Coast seedling fruits, and including collections from Australia and other fruit-growing countries, that are now in the Station nurseries.

In deciding the questions of spelling and nomenclature, the following authorities have been chiefly consulted: Downing's "*Fruits and Fruit Trees of America*"; Thomas' "*American Fruit Culturist*"; Barry's "*Fruit Garden*"; and Wickson's "*California Fruits.*" For seedling fruits not yet described, the authority in every case is the originator or propagator. Reports of other experiment stations and of horticultural societies, and catalogues of almost every prominent nurseryman in the United States and Europe, have also been consulted.

The sign † denotes that the variety named was growing in the orchard of the given station January 1, 1894. The sign — denotes that it is not yet in the orchard; it may be in the Central Station nursery, to be in the outlying orchards by another year. Since every effort is made to select varieties adapted to the several stations, the orchards will never become entirely identical.

APPLES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Acme	—	†	†	—	—
Alexander	†	†	†	†	†
Amassia	†	—	—	†	—
Anisim	†	—	—	†	—
Arabskoe	†	—	—	—	†
Arkansas Black	—	†	†	†	—
Austrian	†	—	†	—	†
Autumn Sweet Bough	†	—	—	—	—
Australian Aphis-Proof	†	†	†	†	†
B. M. (from Budd)	†	—	—	—	†
Babbitt	†	—	—	—	—
Bailey's Sweeting	†	†	†	—	—
Baldwin	†	†	†	—	—
Beauty of Kent	—	†	†	—	—
Belle de Boskoop	—	—	—	—	†
Ben Davis	†	†	†	—	—
Benoni	†	†	†	—	—

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APPLES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Berenice	†	—	—	—	—
Berry Pippin	†	—	—	—	†
Black Warrior	†	—	—	—	—
Bledsoe	—	—	†	†	—
Blue Pearmain	—	—	†	—	—
Borken	†	—	—	—	—
Borsdoffer	†	—	—	—	—
Bradanoff	†	†	—	—	—
Brakefield Seedling	†	—	—	†	—
Brychenoff	†	—	—	—	†
Buckingham (Equinetely)	†	—	—	—	—
Canada Reinette	†	—	—	—	—
Cardinal	†	—	—	—	—
Carlough	—	—	†	—	—
Carolina Red June	†	—	—	—	—
Carolina Watson	†	—	—	—	—
Carter's Blue	†	—	—	—	—
Charlottenthaler	†	—	—	†	—
Chattahoochee	†	—	—	—	—
Chestatee	†	—	—	—	—
Clayton	†	—	†	—	—
Clyman's Pippin	†	—	†	—	—
Cogswell	†	—	—	—	—
Colvert	—	—	†	—	†
Cooper's Market	†	—	—	†	—
Count Orloff	†	—	—	—	—
Dahlonega	†	—	—	—	—
Dickinson	†	†	—	—	—
Disharoon	†	—	—	—	—
Dominie	†	—	—	—	—
Downing's Winter Maiden's Blush	†	—	—	—	†
Duchess of Oldenburgh	†	—	—	—	—
Duckett	†	—	—	—	—
Duke of Devonshire	—	—	†	—	†
Dutch Mignonne	†	—	—	—	—
Early Colton	†	—	—	—	—
Early Harvest	†	—	—	—	—
Early Joe	†	—	—	—	—
Early Ripe	—	†	†	—	†
Early Strawberry	—	†	†	—	—
Edward's Sweet	†	†	†	—	—
Esopus Spitzenberg	†	†	†	†	—
Everbearing	—	—	—	†	†
Excelsior	—	—	—	†	—
Fallawater	†	—	—	—	—
Fall Jenneting	†	—	—	—	—
Fall Pippin	—	†	†	—	—
Fall Wine	†	—	—	—	—
Fameuse (Snow)	†	†	†	†	†
Fanny	†	—	—	—	—
Forest	—	—	†	—	—
Fano	—	—	†	—	—
Garretson's Early	†	—	—	—	—
Gloria Mundi	†	†	†	†	—
Glowing Coal	—	—	†	—	—
Golden Russet (Am.)	†	—	—	—	—
Golden Russet (Eng.)	†	—	†	—	—
Grand Duke Constantine	†	—	—	—	—
Grand Sultan	†	—	—	—	—
Gravenstein	†	†	†	†	†
Grimes' Golden Pippin	†	†	†	†	—
Gros Vor	†	†	†	—	†
Gypsy Girl	†	—	—	—	—
Haas	—	†	†	—	—
Hall	†	—	—	—	—
Hargrove	†	—	—	—	—
Hawthornden	†	—	—	—	—
Herefordshire Beefing	†	—	—	—	—

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APPLES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Hoover	†	—	†	†	†
Hubbardston's Nonesuch	†	—	—	—	—
Huntsman	†	—	†	—	—
Hurlbut	—	†	—	—	—
Ingram	†	†	—	—	—
Jefferis	†	—	—	—	—
Jonathan	†	†	†	†	†
Julian	†	—	—	—	—
Keswick Codlin	—	—	—	—	—
King	—	†	†	—	—
King of Tompkins County	†	—	—	—	—
Kirkbridge White	†	—	—	—	—
Lady	†	†	—	†	—
Lady's Sweeting	—	†	†	—	—
Lankford	†	†	†	†	†
Lawver	—	†	†	†	†
Limber Twig	—	†	†	—	—
Lincoln	—	—	†	†	—
Lowell	†	—	—	—	—
Loy	—	†	†	†	—
Lyman's Pumpkin Sweet	†	—	—	—	—
Maiden's Blush	†	†	†	—	—
Mangum	†	—	—	—	—
Mann	—	†	†	—	—
Mammoth Black Twig	†	—	—	—	†
Marshall's Seedling	†	—	†	†	†
Maverack Sweet	†	—	—	—	—
McCloud's Family	†	—	—	—	—
McLellan	†	—	—	—	—
McMahon's White	—	†	†	—	†
Munson Sweet	†	—	—	—	—
Merkley's Red	†	—	—	—	—
Missouri Pippin	—	†	†	†	†
Montreal Beauty	—	—	†	†	—
Morton's Pearmain	—	†	†	—	—
Mother	†	†	†	—	—
Nantahalee	†	—	—	—	—
Nero	—	—	—	—	†
Nickajack	—	—	†	—	—
Northern Spy	†	—	†	†	†
Ortley	†	†	†	—	†
Pear Apple	†	—	—	—	—
Peck's Pleasant	†	†	†	—	—
Perry Russet	—	†	†	—	†
Persian	†	—	—	—	—
Pewaukee	†	—	†	†	†
Pigeon	†	—	—	—	—
Pine Stump	†	—	—	—	—
Pointed Pippin	†	†	†	†	†
Pomme Grise	†	—	—	—	—
Pomme Royale	†	—	—	—	—
Porter	†	†	†	—	—
Primate	†	—	—	—	—
Prior's Red	†	†	†	—	—
Pumpkin Sweet	†	—	—	—	—
Rambo	†	†	†	—	—
Rawle's Janet	—	†	—	—	—
Red Astrachan	†	†	†	†	†
Red Autumn Calville	†	—	—	—	—
Red Bietigheimer	—	—	†	†	†
Red Canada	†	†	—	—	—
Red-cheeked Pippin	—	†	†	—	—
Red Fall Pippin	†	—	—	—	—
Red June	—	—	†	—	—
Red Warrior	†	—	—	—	—
Red Winter Pearmain	—	—	†	†	—
Reinette Bauman	†	—	—	—	—
Reinette de Caux	—	†	—	—	†

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APPLES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Rhode Island Greening	†	†	†	—	†
Ribstone Pippin	—	†	†	—	—
Rome Beauty	†	†	†	—	—
Rosa Ripka	†	—	—	—	†
Roxbury Russet	†	†	†	—	—
Ruby Gem	—	—	†	—	—
Seedless	†	—	—	—	—
Seek-No-Further	†	—	—	—	—
Serinka	†	—	—	—	—
Shackleford	†	†	†	—	—
Shannon	†	—	†	†	†
Sherwood's Favorite	†	—	—	—	—
Shirley	—	—	†	†	—
Skinner's Seedling	†	†	†	—	†
Smith's Cider	†	—	—	†	†
Smokehouse	†	—	—	—	—
Sonoma (Cook's Seedling)	—	†	†	†	†
Sops of Wine	†	—	—	—	—
Stark	—	†	†	—	—
Stevens' Rareripe	—	—	—	†	—
St. Lawrence	†	—	—	—	—
Stump	—	—	†	†	†
Summer Hagloe	†	—	—	—	—
Summer Queen	†	—	—	—	—
Swaar	†	†	†	—	—
Sweet June	†	†	—	—	—
Talman's Sweeting	†	†	†	—	—
Trenton Early	—	†	—	—	†
Twenty-Ounce	—	†	†	†	†
Vandevere	†	—	†	—	—
Violet	†	†	----------	†	—
Virginia Greening	†	—	—	—	—
Wagener	†	†	†	—	—
Walbridge	—	†	—	—	†
Waldo	†	—	—	—	—
Wall	†	—	—	—	—
Wealthy	—	†	†	†	†
Wells Sweet	†	—	—	—	—
White Astrachan	—	—	—	†	—
White Pippin	†	—	—	—	—
White Winter Pearmain	†	†	†	†	†
Willow Twig	†	—	—	—	—
Winesap	—	†	†	—	—
Winter Banana	—	†	†	—	—
Wolf River	—	†	†	†	—
Wythe (Pittsburgh Pippin)	—	—	—	†	—
Yellow Bellflower	†	—	†	†	—
Yellow Newtown Pippin	—	†	†	†	†
Yopp's Favorite	†	—	—	—	—
York Imperial	—	†	—	—	—
Zuzoff Winter	†	—	—	—	†
12 M (from Budd, Iowa)	†	†	†	—	—
15 M (from Budd, Iowa)	†	†	†	—	—

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CRAB APPLES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Chicago	†	—	—	—	—
Coral	†	—	—	—	—
Currant	†	—	—	—	—
Hew's Virginia	†	—	—	—	—
Hyslop	†	†	†	—	†
Lady	†	—	—	—	—
Large Red	†	—	—	—	—
Large Yellow	†	—	—	—	—
Malus Carda	†	—	—	—	—
Malus Floribunda Atropurpurea	†	—	—	—	—
Malus Kaida	†	—	—	—	—
Montreal Beauty	†	—	—	—	†
Oblong	†	—	—	—	—
Red Siberian	†	—	†	—	—
Ringo	†	—	—	—	—
Transcendent	†	†	†	—	†
Whitney	—	—	†	†	†
Yellow Siberian	—	—	—	†	†

ALMONDS.

Bidwell's Mammoth	—	†	†	†	—
Commercial	—	†	†	—	†
Coppin's Seedling	†	—	—	—	—
Drake's Seedling	—	†	†	—	†
Flat-Fruited	—	†	†	—	†
Golden State	—	†	†	—	†
Hatch's Seedling No. 2	†	—	—	—	—
Harriott's Seedling	—	†	†	†	—
I X L	—	†	†	†	†
King's Soft-shell	—	†	†	—	†
Languedoc	†	†	†	—	†
Lewelling Prolific	†	†	—	—	†
Loomis' Seedling	†	—	—	—	—
Marie Dupreys	—	†	†	—	†
Ne Plus Ultra	—	†	†	†	†
Nonpareil	—	†	†	†	†
Paper-shell	—	†	†	†	†
Pistache	—	†	†	—	†
Routier's Twin	—	†	—	†	—
Silver-shell	—	—	—	—	†
Sultana	—	†	†	—	†
Texan Prolific					
Wolfskill	—	†	—	—	—

APRICOTS.

Alberge de Montgamet	†	—	—	†	—
Beauge	—	†	†	†	—
Blenheim (Shipley)	†	†	†	†	†
Boulbon	—	†	—	†	—
Briggs' White	†	—	—	—	—
Breda	†	†	†	†	—
Brigitta's French	—	†	—	—	†
Canino Grosso	†	†	—	†	—
De Couforge	†	†	†	†	†
Early Golden	†	—	†	—	—
Early Moorpark	†	—	—	†	†
Early Rivers	—	†	—	—	†
Esperen	—	†	—	—	—
Flickinger	—	†	—	†	†
Gold Dust	—	†	—	—	†
Gooley	—	†	—	—	†
Hemskirke	†	†	†	†	†

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APRICOTS—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Hind's	—	—	†	—	†
Hubbard	—	†	†	—	†
Jamucett	†	—	—	—	—
Kaisha	†	†	†	†	†
Kell's Peach	—	†	†	†	—
King's Seedling	†	—	—	†	—
Large Early	†	—	—	†	—
Luizet	—	†	†	†	†
Long Red	†	—	†	†	—
Malcom's Breda	†	—	†	—	—
Montgamet	—	†	†	†	†
Moorpark	—	†	†	†	†
Musch-Musch	—	—	†	†	—
Musk—Early	—	—	—	—	†
Newcastle	—	†	†	—	†
Orange	—	—	†	—	—
Oullin's Golden	†	†	—	†	†
Peach	—	†	†	†	—
Pringle	—	—	†	†	†
Purple, or Black	†	†	†	—	—
Red Masculine	†	†	†	†	—
Royal	—	†	†	†	—
Routier's Peach	—	—	†	†	—
Russian	†	—	—	†	—
Turkey	†	†	†	—	†
St. Ambroise	†	†	†	†	†
Sardinian	†	†	†	†	†
Shensi	†	†	†	†	†
Spark's Mammoth	†	†	†	—	—
Smith's Triumph	—	—	†	†	†
Viard	—	—	†	†	†

CHERRIES.

Abeso	—	—	†	†	†
Amarelle Bunt	†	†	†	—	†
American Heart	†	—	—	—	—
Baumann's May	—	†	†	—	—
Belle Crown	†	†	—	—	—
Belle d'Orleans	—	†	†	—	—
Belle Magnifique	†	†	†	—	†
Bessarabian	—	—	—	†	—
Bigarreau Noir Hâtif	†	—	—	†	—
Bigarreau Riverchon	†	—	—	—	—
Black Eagle	—	—	†	—	—
Black Mastodon	—	†	†	—	—
Black Tartarian	†	†	†	†	†
Brant	†	—	—	—	—
Burr's Seedling	—	†	†	—	—
Buttner's Yellow	†	—	—	—	—
California Advance	†	†	—	—	—
Centennial	†	†	†	—	†
Chapman	†	—	†	—	—
Cleveland Bigarreau	—	†	—	—	—
Coe's Transparent	—	†	†	—	—
Duchesse de Palluau	—	†	†	—	—
Downer's Late Red	†	†	—	—	—
Early Lamaurie	†	—	—	—	—
Early Purple Guigne	—	†	†	—	—
Early Richmond	—	†	—	—	—
Early Rivers	—	†	†	—	—
Elton	†	†	—	—	†
Empress Eugenie	—	†	†	†	—
English Morello	—	†	†	—	—
Frogmore Bigarreau	†	—	—	†	—
George Glass	†	†	†	†	†

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CHERRIES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-(Chino.)
Governor Wood	†	†	†	—	—
Great Bigarreau	—	†	†	—	—
Gridley	†	—	—	—	—
Griotte Précoce	†	†	—	†	†
Guigne Tres Précoce	—	†	†	—	†
Kanawha	†	—	—	—	—
King's Amarelle	†	†	†	†	†
Knight's Early Black	†	†	†	†	—
Lewelling	—	†	†	—	—
Lincoln	—	†	—	—	—
Major Francis	—	†	†	—	—
Manning's Mottled	†	—	—	—	—
May Duke	†	†	†	—	—
Merveille de Septembre	†	—	—	—	—
Monstreuse de Mezel	†	—	—	—	—
Napoleon Bigarreau	—	†	†	—	†
Newcastle	—	†	—	—	—
Nouvelle Royale	—	†	—	—	—
Olivet	—	†	†	—	—
Oregon	—	—	†	—	—
Pontiac	—	†	†	—	—
Purity	—	†	†	—	—
Qutorka	†	—	†	—	†
Reine Hortense	—	—	†	—	—
Richmond	—	—	—	—	†
Rockport Bigarreau	†	†	†	—	†
Rostraver Bigarreau	†	—	—	—	—
Schmidt's Bigarreau	—	†	†	—	—
Slanka	†	—	—	†	†
Tarascon Early	—	†	—	—	—
Thompson's Seedling	†	—	†	—	—
Tradescant Black Heart	—	†	†	—	—
Vilne Sweet	—	—	—	—	†
Werder's Early Black Heart	—	†	†	—	—
Willamette	—	†	†	—	†
Windsor	—	†	†	—	—
Yellow Glass	†	†	†	†	†
Yellow Spanish	—	†	†	—	—

CHESTNUTS.

American Sweet	—	†	†	—	—
Italian	—	†	—	—	†
Japan Giant	—	—	—	—	†
Marron de Lyon	—	†	—	—	†
Numbo	—	†	—	—	†

CITRON.

Amalfi	—	—	—	—	†
Sorrento	—	—	—	—	†

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FIGS.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Abondance Précoce	—	†	—	†	†
Agen	—	†	†	†	†
Angelique	—	†	†	†	†
Bellona	—	—	—	—	†
Black Bourjassotte	—	†	†	†	—
Black California	—	†	†	†	—
Black Dattato	—	†	—	†	†
Black Havana	—	—	—	—	†
Black Ischia	—	†	—	†	†
Black Marseilles	—	†	†	†	—
Bourjassotte Gris	—	—	—	—	†
Bourjassotte Panachée	—	—	—	—	†
Breba	†	†	—	†	†
Brianzola	—	†	—	—	†
Brogiotto (black)	—	—	—	—	†
Brogiotto (white)	—	—	—	†	†
Brown Turkey	—	†	†	†	†
Brown Ischia	—	†	—	†	†
Brunswick	—	†	†	†	†
Buissonne	—	—	—	—	†
Capri (wild fig)	—	†	†	†	†
Cernica	†	†	†	†	—
Col di Signora Bianca	—	†	—	†	†
Col di Signora Nero	—	†	†	†	—
Coucourelle Noire	—	—	—	—	†
Dalmatian	—	†	†	†	—
De Constantine	—	†	†	†	†
Dorée Narbus	—	†	—	†	—
Drap d'Or	—	†	—	†	—
Du Roi	†	†	†	†	†
Early Violet	—	†	—	†	—
Ford's Seedling	—	—	—	—	†
Gros Gris Bifere	—	†	—	†	†
Grossale	—	—	—	†	—
Guiglione	—	†	—	—	†
Hirtu du Japon	†	†	†	†	†
Ladora	—	†	—	†	†
Magdalen	—	—	—	—	†
Monaca Bianca	—	†	†	†	†
Negro Largo	—	†	†	†	†
Nepolitaine	—	—	—	—	†
Noir Moutier	—	—	—	—	†
Osborne Prolific	—	†	†	†	†
Pacific White	†	—	—	—	—
Pagandiere	—	—	—	—	†
Pasteliere	—	†	†	†	†
Petrovaca	†	†	—	†	—
Pargigna	†	†	—	†	†
Pocardi	—	†	†	†	—
Ponde Noir	†	†	†	†	†
Ponde Violette Hâtive	—	†	—	†	†
Poyal Vineyard	—	—	—	†	†
Pubado	—	†	—	—	†
Pan Pedro	—	†	†	†	†
Panvito	—	†	—	—	—
Pnyrna (California)	—	†	—	†	†
Pnyrna (Bulletin)	—	†	†	†	†
Projano	—	†	—	†	†
Perdal Longue	—	—	—	—	†
Phite Adriatic	†	†	†	†	†
Phite Genoa	—	†	†	†	†
Phite Ischia	—	†	†	†	†
Phite Marseilles	—	†	†	†	†
Phite Nerii	†	—	—	—	—
Phite Smyrna	†	†	—	—	†
Pllow Celestial	—	—	—	†	†
Pmeia	†	†	—	†	—

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LEMONS.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Bonnie Brae	—	—	—	—	†
Eureka	—	—	—	—	†
Genoa	—	—	—	—	†
Lisbon	—	—	—	—	†
Royal Messina	—	—	—	—	†
Villafranca	—	—	—	—	†

MULBERRIES.

Alba	†	—	†	†	—
Downing's	†	†	†	†	—
Italian Dwarf	†	†	†	—	—
Lhoo	†	†	†	†	—
Multicaulis	†	†	†	†	—
Moretti	†	†	†	—	—
Nagasaki	†	†	†	†	—
Persian	†	—	†	†	—
Russian	†	—	†	†	—
Stubbs	†	—	—	—	—

NECTARINES.

Balgowan	—	—	†	—	†
Boston	—	—	†	†	—
Coosa	†	—	—	—	—
Downton	†	—	†	†	†
Duc de Vitry	†	—	†	—	—
Early Newington	†	†	†	†	†
Early Violet	—	†	—	†	—
Elruge	—	—	—	—	†
Hardwicke	—	—	†	†	—
Lord Napier	†	†	†	†	—
Monicourt Vinous	†	—	—	—	—
New White	†	†	†	†	—
Olmstead	—	†	†	—	†
River's Orange	†	—	—	—	†
Red Roman	—	—	†	—	†
Stanwick	—	—	†	†	†
Victoria	†	†	†	†	†

ORANGES.

Florida Sour	—	—	—	†	†
Hart's Tardive	—	—	—	—	†
Homosassa	—	—	—	—	†
Jaffa	—	—	—	—	†
King	—	—	—	—	†
Kin-Kin (round)	†	—	—	—	—
Kin-Kin (oval)	†	—	—	—	†
Kino-Kuni	—	—	—	—	†
Konah	—	—	—	—	—
Magnum Bonum	—	—	—	—	†
Malta	—	—	—	—	†
Mediterranean Sweet	—	—	—	—	†
Oonshiu	†	†	—	†	†
Parson Brown	—	—	—	—	†
Pineapple	—	—	—	—	†
Ruby Blood	—	—	—	—	†
Seedlings in variety	†	†	—	†	†
St. Michaels	—	—	—	—	†
Tangerine	—	—	—	—	†
Washington Navel	—	—	—	—	†

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PEACHES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Acton Scott	—	†	—	—	—
Alberge	†	†	—	†	—
Albright's Cling	—	†	†	—	—
Alexander	—	†	†	†	†
Amelia	—	†	—	†	—
Amsden's June	—	†	†	—	†
Atlanta	†	—	—	—	†
Baldwin's Late	—	†	—	†	†
Beer's Smock	—	†	†	†	—
Belle Bauce	†	†	†	†	—
Belle Bouquet	—	†	—	—	—
Belle Coquette	†	—	—	—	—
Belle de la Croix	—	†	—	†	—
Belle Douai	†	—	†	†	—
Bergen's Yellow	†	—	—	—	—
Bilyeu's Late	†	†	—	—	—
Bishop's Early	—	†	—	†	—
Bonanza	—	†	†	†	—
Brandywine	—	†	†	†	—
Brevoort	†	—	—	†	—
Briggs' May	†	†	†	—	†
Brook's Butte	—	†	†	—	†
Buck's Prolific	†	†	†	—	†
Burke Cling	—	—	—	†	†
California Cling	—	†	†	†	†
Canada Cling	†	†	—	†	—
Carmine	†	†	—	—	†
Chair's Choice	—	†	—	†	—
Chinese Cling	—	†	†	†	†
Chevreuse Hâtive	†	†	—	†	—
Cole's Early Red	†	†	—	—	—
Columbia	—	†	†	—	—
Comet	†	—	—	—	†
Cooledge's Favorite	†	†	†	†	†
Crawford Early	—	†	†	†	†
Crawford Late	—	†	†	†	†
Crimson Beauty	—	†	†	†	—
Crimson Galande	†	—	—	—	—
Crosby	†	—	—	†	—
Dagmar	†	—	—	—	†
Delaney Heath Cling	†	—	—	—	—
De la Regandiere	—	†	—	—	—
Dr. Hogg	†	—	—	†	—
Dr. Pilkington (seedling)	†	—	—	†	†
Early Albert	—	†	—	—	—
Early Alfred	†	—	—	†	†
Early Beatrice	†	†	—	—	—
Early Charlotte	†	†	—	—	—
Early Louise	†	—	—	—	—
Early Grosse Mignonne	—	—	†	—	—
Early Rivers	—	†	†	†	—
Early Rose	†	†	—	†	—
Early Savoy	†	†	—	—	—
Early Silver	†	†	—	—	—
Early Victoria	†	†	—	—	—
Early York	†	†	—	—	—
Edith Cushing	†	—	—	—	—
Elberta	—	†	†	†	—
Ford's Improved	—	—	—	†	†
Foster	†	†	†	†	†
Geary's Hold On	—	†	†	—	—
George's Late Cling	—	†	†	†	—
George IV	†	†	—	—	—
General Bidwell (of California)	—	†	†	—	—
General Lee	†	—	—	—	—
Golden Cling	—	—	—	†	—
Gold Dust Cling	†	†	—	†	†
Governor Briggs	—	—	—	†	—

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PEACHES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Governor Garland	—	†	†	†	†
Gresham	—	—	—	†	†
Grover Cleveland	—	†	†	†	—
Grosse Mignonne	—	—	—	†	†
Haine's Early	—	—	†	†	†
Hale's Early	—	—	—	†	—
Heath Cling	†	†	—	—	—
Heath Free	†	—	—	—	—
Henrietta	†	†	†	†	†
Hisk's Seedling	†	†	—	—	—
Hill's Madeira	†	—	—	—	—
Honest Abe	—	†	†	—	—
Honey Cling	—	†	†	—	—
Indian Blood	—	†	†	†	†
Italian Dwarf	—	—	†	—	—
Jacques Rareripe	†	†	—	—	—
Japan Blood	—	†	†	—	—
Jennie Worthen	—	†	†	†	—
Jones' Seedling	†	—	—	—	†
Lady Palmerston	†	—	—	—	—
La Grange	—	†	†	†	—
Large Early Mignonne	†	—	—	†	—
Large Early York	†	†	†	†	†
Large White Cling	—	†	†	—	—
Late Admirable	—	†	†	†	†
Late Morris White	†	—	—	—	†
Lemon Cling	†	†	†	†	†
Lemon Free	—	†	—	†	—
Leopard	†	—	—	—	—
Leopold I.	†	—	—	—	—
Lovell	—	†	†	†	†
Lovett's White	†	—	—	†	†
Lyon Cling	—	—	†	—	—
Malta	†	—	—	—	—
Mammoth Melocoton	†	—	—	—	—
Marshall's Late	—	—	—	†	†
Mary's Choice	—	†	—	†	—
McDevitt's Cling	—	†	†	—	†
Magdala	—	—	—	†	—
McKevitt's Cling	†	†	†	†	†
McKevitt's Free	—	—	—	—	†
Miss Lola	—	†	—	—	†
Monstreuse de Doue	†	—	—	—	—
Moore's Favorite	†	†	†	—	—
Morris White	†	†	†	†	†
Mountain Rose	†	†	†	†	†
Mrs. Brett	—	†	†	—	—
Muir	†	†	†	†	†
Muscogee	†	—	—	—	—
Newhall	—	†	†	†	†
Newington	—	†	†	—	—
Nichols' Orange Cling	†	†	†	†	†
Noblesse	—	†	†	†	—
Oldmixon Cling	†	†	†	†	†
Oldmixon Free	†	†	†	†	—
Pansy Pabor	—	†	—	†	†
Peen-To	†	†	—	†	—
Picquet's Late	†	†	†	†	†
President	†	—	†	—	—
Pucelle de Malines	†	†	—	†	†
Pymrod	†	—	—	—	—
Raymackers	†	—	—	†	—
Red River	—	†	—	†	—
Richmond	†	†	—	†	—
Roseville Cling	†	—	—	†	—
Royal George	—	†	†	†	—
Royal Kensington	†	—	—	—	—
Runyon's Orange Cling	—	†	†	—	†

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PEACHES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Salway	†	†	†	†	†
Scrugg's	—	†	—	†	—
Seller's Cling	†	†	†	†	†
S. G. French	—	†	—	†	—
Shark's Prolific	—	—	—	—	†
Schumacker	—	†	†	†	—
Smock Late Free	†	†	—	†	†
Sneed	†	†	†	—	†
Snow	†	—	—	†	—
Spottswood	†	—	—	—	—
Staley's Seedling	†	—	—	—	†
St. Ascycles	—	—	—	—	†
Strawberry	†	†	†	—	—
Stump the World	†	†	†	†	†
Surpasse Melocoton	†	—	—	—	—
Susquehanna	—	†	†	†	†
Thissell's Free	—	†	†	†	†
Tippecanoe	†	—	—	—	†
Troth's Early	†	—	—	—	—
Tuscany Cling (Tuskena?)	†	†	†	—	—
Ulatis	—	†	†	†	—
Van Buren's Golden Dwarf	†	—	—	—	—
Wager	—	†	†	—	—
Ward's Late Free	†	†	†	†	†
Waterloo	—	†	†	†	†
Wheatland	†	†	†	†	—
White Imperial	†	—	—	—	—
White Melocoton	†	†	—	—	—
White Tuscan Cling	—	†	—	—	—
Wilkins' Cling	—	†	†	†	—
Wonderful	—	†	—	†	—
Yellow St. John	†	†	†	†	†
Yellow Tuscany Cling	†	—	—	†	†

PEARS.

America	†	—	—	—	—
Amire Joannet	†	—	—	—	—
Ananas d'Eté	†	—	—	—	—
André Desportes	—	†	—	†	—
Andrews	†	—	—	—	—
Anna Nelis	†	†	†	—	†
Anne Ogereau	—	—	—	†	—
Augustus Dana	†	—	—	—	†
Baronne de Mello	†	—	—	—	†
Bartlett	†	†	†	†	†
Beaupresent d'Artois	†	—	—	†	—
Belle Lucrative	†	—	†	†	—
Belle Williams	†	—	—	—	—
Bergamotte Cadet	†	—	—	—	—
Bergamotte d'Esperen	†	—	—	—	—
Beurré Amande	†	—	—	—	—
Beurré Bosc	†	—	†	†	†
Beurré Clairgeau	†	†	†	†	†
Beurré d'Amanlis	—	†	†	†	—
Beurré d'Anjou	†	—	†	†	†
Beurré d'Aremberg	†	—	—	—	—
Beurré Assomption	†	—	—	†	†
Beurré de Waterloo	†	—	—	†	—
Beurré Diel	†	—	†	†	—
Beurré Easter	†	—	†	†	†
Beurré Giffard	†	—	†	†	†
Beurré Golden of Bilbao	†	—	—	—	†
Beurré Goubalt	†	—	—	—	—
Beurré Gris	—	—	†	†	†
Beurré Gris d'Hiver Nouveau	†	†	—	†	—

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PEARS—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Beurré Hardy	†	—	†	†	†
Beurré Langlier	†	—	—	†	—
Beurré Précoce	†	—	—	—	—
Beurré Sterkmans	†	—	—	—	—
Beurré Superfin	†	—	†	†	—
Bezi Sanspareil	†	—	—	—	—
Black Worcester	—	—	†	†	—
Blanquette	—	†	—	—	†
Bloodgood	†	†	—	†	—
Bonne d'Ezée	†	—	—	—	—
Bonne du Puits Ansault	†	—	—	—	†
Bonne Sophie	†	—	—	—	—
Brandywine	†	—	—	—	—
Brockworth Park	†	†	†	—	†
B. S. Fox	—	—	†	†	†
Buffum	†	—	—	—	—
Calabasse Monstreuse	†	—	—	—	—
Canandaigua	†	—	—	—	—
Chaptal	†	—	—	—	—
Chaumontel	†	—	—	—	—
Clapp's Favorite	†	†	†	†	†
Cole	—	†	†	†	†
Colonel Wilder	—	—	—	†	—
Columbia	†	—	†	†	—
Conseiller de la Cour	†	†	†	†	†
Courte Queue d'Automne	†	—	—	—	†
Dana's Hovey	†	—	†	—	—
Dearborn's Seedling	†	—	†	†	—
De Tongres	†	†	†	†	†
Directeur Alphand	—	†	—	—	†
Dix	†	†	†	†	—
Doyenne Boussock	†	—	†	—	—
Doyenne d'Alençon	†	†	†	†	—
Doyenne d'Eté	†	—	†	†	—
Doyenne du Comice	†	—	†	†	—
Doyenne Robin	†	—	—	—	—
Doyenne Sieulle	†	—	—	—	—
Doyenne White	†	—	—	†	—
Dr. Reeder	†	—	—	†	†
Duchesse d'Angoulême	†	—	†	†	†
Duchesse de Mouchy	†	—	—	—	†
Duchesse de Berry d'Eté	†	—	—	—	—
Duchesse d'Orleans	†	—	—	—	†
Duchesse of Bordeaux	†	—	—	—	†
Duchesse Précoce	†	—	—	—	—
Duhamel du Monceau	†	—	—	—	†
Emile de Heyst	†	—	—	†	—
Epine Dumas	†	—	—	—	†
Eugene Appert	†	—	—	—	†
Figue d'Alençon	†	—	—	—	†
Flemish Beauty	†	†	—	†	†
Fondante de Noël	†	—	—	—	†
Fondante Fougere	†	—	—	—	—
Forelle	†	†	†	†	—
Frederick Clapp	—	†	—	†	†
Fulton	†	—	—	—	—
Gansel's Bergamotte	—	—	†	†	—
Glout Morceau	†	—	†	†	†
Gratiola, of Jersey	†	—	—	—	—
Gray Doyenne	†	—	†	†	†
Hawaii	†	—	—	—	—
Henry IV	†	—	†	†	†
Howell	†	—	—	†	†
Idaho	†	—	†	†	—
Inconnue	†	—	—	—	—
Jalousie de Fontenay Vendée	†	—	—	—	†
Jaminette	†	—	†	†	—
Japan Seedlings	—	†	†	—	—

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PEARS—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare)	Southern California Station. (Pomona-Chino.)
Jean de Witte	—	—	†	†	—
Jones' Seedling	†	—	—	—	†
Josephine de Malines	—	†	†	†	—
Keiffer	†	†	†	†	—
Kennedy	—	—	†	†	—
Kingsessing	†	—	—	—	—
Kirtland	†	—	—	—	—
Lankford	†	—	†	—	—
Lawrence	†	—	†	†	†
Lawson or Comet	—	—	†	†	†
Le Conte	†	†	†	†	†
Levard	†	—	—	—	†
Liberale	†	—	—	—	—
Louise Bonne de Jersey	†	—	†	†	—
Louis Vilmorin	†	—	—	—	†
Madame Cuissard	†	—	—	—	—
Madame Loriol de Barney	†	—	—	—	†
Madame Treyve	†	—	—	—	†
Madeleine	†	†	†	†	†
Manning's Elizabeth	†	—	—	—	—
Maréchal Vaillant	†	—	—	—	†
Marie Louise d'Uccles	†	—	—	—	†
Maurice Desportes	†	—	—	—	—
Mount Vernon	†	†	†	†	†
Moyamensing	†	—	—	—	—
Nantais	†	—	—	—	—
Napoleon	†	—	—	—	†
Nouveau Poiteau	†	†	†	†	—
Onondaga	—	—	†	†	—
Osband's Summer	†	—	†	†	†
Oswego Beurré	†	—	—	—	—
Ott	†	—	—	—	—
Paradise d'Automne	†	†	†	†	†
Passe Colmar	†	—	—	—	†
Pater Noster	†	—	—	—	†
Paul Ambre	†	—	—	—	—
P. Barry	†	†	†	†	†
Petite Marguerite	†	—	—	—	—
Pitmaston's Duchesse d'Angoulême	†	—	—	—	†
Pound	†	—	—	†	—
Pratt	†	—	—	†	—
Prince's St. Germain	†	—	—	—	—
Rostiezer	†	—	—	—	—
Rousselet Stuttgart	†	—	—	—	—
Rutter	†	—	—	—	—
Santa Ana	†	—	—	—	—
Sarah	†	—	—	—	†
Seckel	†	—	†	†	†
Sheldon	†	†	—	†	—
Smith's Hybrid	—	—	—	—	—
Souvenir d'Esperen	†	—	—	—	†
Souvenir du Congrès	†	—	†	†	†
St. André	†	—	—	—	†
Star of Bethlehem	—	—	—	—	†
St. Crispin	†	—	—	—	†
Steven's Genessee	†	—	—	—	—
St. Germain	†	—	—	—	—
St. Michael Archange	†	—	—	—	†
Swan's Orange	†	—	—	—	—
Theresa Appert	—	—	—	—	†
Tyson	†	—	†	†	†
Urbaniste	—	—	†	†	—
Van Mons' Leon le Clerc	—	—	†	†	†
Vicar of Winkfield	†	—	—	†	†
Washington	†	—	—	—	—
Winter Nelis	†	†	†	†	†
Winter Seckel	—	†	†	†	†
Williams d'Hiver	†	—	—	—	†

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PLUMS AND PRUNES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Autumn Gage	†	†	†	—	—
Autumn Compôte	†	—	—	—	—
Barbat d'Ente	†	—	—	†	†
Barry	—	—	†	—	—
Bassford Prune	—	†	—	—	—
Bavay's Green Gage	—	†	†	†	†
Belgian Purple	†	†	†	—	†
Belle de Septembre	†	†	†	†	†
Blackman	†	†	†	†	—
Bleeker's Gage	†	†	†	—	—
Blue Damson	†	†	†	†	†
Botan	—	†	†	†	†
Botankio	†	†	†	†	†
Bradshaw	†	†	†	†	†
Brignole	—	†	†	—	†
Bryanston's Gage	†	—	†	†	†
Bulgarian Prune	†	†	†	†	†
Burbank	†	†	†	—	†
Caddo Chief	—	—	—	†	—
California Red	—	—	—	†	—
Chabot Blood	†	†	—	†	—
Chapman's Black	—	—	—	†	—
Cherry	—	†	—	†	—
Clyman	—	†	†	†	—
Coe's Golden Drop	†	†	†	†	†
Coe's Late Red	—	†	—	†	†
Columbia	†	†	†	†	—
Copper	†	†	†	†	†
Cumberland	†	—	—	—	—
Czar	—	†	†	†	†
Damas Noir	—	—	†	†	—
Datte de Hongrie	†	†	†	†	†
D'Ente de Puymirol	†	†	—	—	†
Dennison's Superb	†	—	†	—	†
Diamond	†	†	†	†	—
Diaprée Rouge	—	†	†	†	—
Drap d'Or d'Esperen	†	†	†	—	†
Duane's Purple	†	†	†	†	†
Early Gilt	†	—	—	—	—
Early Golden Drop	—	†	—	†	—
Elmore	—	†	†	†	—
Fellenberg (Italian)	†	†	†	†	†
General Hand	†	†	†	†	†
German Prune	†	†	†	†	†
Glaister	†	—	†	—	†
Golden Beauty	—	—	—	†	—
Golden Prune	†	—	†	†	—
Goliath	†	—	†	—	†
Grand Duke	—	†	—	—	†
Green Gage	†	—	†	†	†
Grosse Prune d'Agen	†	†	†	†	†
Guthrie's Late Green	†	†	†	†	†
Hungarian Prune	—	—	—	†	—
Hattankio	—	—	†	—	—
Holman	—	†	†	—	—
Ickworth's Imperatrice	—	†	†	†	†
Imperial Gage	†	†	†	†	—
Ive's Autumn	†	†	†	—	†
Japan No. 3	—	—	†	—	—
Jefferson	†	†	†	†	†
Judson	†	—	—	†	†
Kelsey	†	†	†	†	†
Lawrence's Favorite	†	—	—	†	—
Leipsic	†	†	†	†	—
Lombard	†	†	†	—	†
Lone Star	†	—	—	†	—
Long-Fruited Japan	†	†	†	—	†
Lot D'Ente	†	†	—	—	†

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PLUMS AND PRUNES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Lucombe's Nonesuch	†	—	†	†	†
Marianna	†	†	†	†	†
Masu	†	†	†	†	†
McLaughlin	†	†	†	†	†
Monroe Gage	†	†	†	†	†
Morocco	†	†	†	†	†
Myrobalan	†	—	†	—	—
New Black Bullace	†	—	—	†	†
Ogon	†	†	†	—	—
Ontario	†	—	†	†	—
Orange	†	†	†	—	†
Oullin's Golden	—	†	†	†	†
Peach Plum	†	†	†	†	—
Perdrigon Blanc	—	†	†	†	†
Petite Prune d'Agen (French Prune)	†	†	†	†	†
Peter's Yellow Gage	†	†	†	†	†
Précoce de Bergthold	—	†	†	†	†
Prince Engelbert	†	†	†	†	†
Prince of Wales	—	†	†	†	†
Prince's Yellow Gage	†	†	†	—	†
Prunus Simoni	†	†	†	†	†
Purple Favorite	—	†	—	—	—
Prunus Pissardi	—	—	—	†	—
Quackenboss	†	†	†	†	†
Red Gage	—	—	†	—	—
Red Magnum Bonum	†	†	†	†	†
Reine Claude de Bavay	†	†	†	†	†
River's Early Prolific	—	—	†	†	†
Robe de Sergent	—	†	†	†	—
Ronald's Fancy	†	†	—	†	—
Royale de Tours	†	†	†	†	—
Royal Hâtive	—	†	†	†	†
Ruby	—	†	—	†	—
Saint Catherine	—	†	†	†	†
Saint Martin	†	†	†	†	†
Satsuma	—	—	—	†	—
Shiro	—	—	†	—	—
Shropshire Damson	†	†	†	†	†
Silver Prune	†	†	†	†	—
Smith's Orleans	—	†	†	—	†
Stark's Green Gage	—	†	—	†	—
St. Lawrence	†	†	†	—	†
Tennant Prune	†	—	—	—	—
Tragedy	†	†	†	—	†
Transparent Gage	†	—	—	—	—
Uncle Ben	—	—	†	—	—
Ungarish Prune	†	—	†	†	—
Victoria	—	†	†	†	†
Wangenheim	†	†	†	†	—
Washington	†	†	†	†	†
Weedsport	†	—	—	—	—
Wild Goose	†	—	—	—	—
Winesour	†	†	—	—	†
Wyat	†	†	†	†	—
Yellow Gage	†	†	†	†	†
Yellow Magnum Bonum	†	†	†	†	†

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PERSIMMONS.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
American	†	†	—	†	†
Japanese—Dai Dai Maru	†	†	—	—	—
Japanese—Hyakume	†	†	—	—	—
Japanese—Kuro Kume	†	†	—	—	—
Japanese—Layi	†	†	—	—	—
Japanese—Tsuro Noko	†	†	—	—	—
Japanese—Yemon	†	†	—	—	—

QUINCES.

Angers	—	†	—	—	—
Chinese	†	†	†	—	—
Champion	—	†	†	—	—
Meech's Prolific	—	—	†	—	—
Orange	—	†	—	†	—
Portugal	—	—	†	—	—
Rea's Mammoth	—	†	†	—	—
Smyrna	—	—	—	—	†

WALNUTS.

Black Californian	—	†	—	†	—
Black Eastern	—	†	—	—	—
Common English	—	†	—	†	†
French Bijou	—	†	—	—	†
French Chaberte	—	†	—	—	†
French Franquette	—	†	—	—	†
French Mayette	—	†	—	—	†
French Mésange	—	—	—	—	†
French Meylan	—	—	—	—	†
French Parisienne	—	—	—	—	†
French Præparturiens	—	†	—	—	†
French Præparturiens (large-fruited)	—	—	—	—	†
French Præparturiens (cluster)	—	—	—	—	†
French Præparturiens (weeping)	—	—	—	—	†
French Serotina	—	†	—	—	†
French Vourey	—	†	—	—	†
Japanese (Sieboldii)	†	—	—	—	—
Persian (Kaghazi)	—	†	—	—	—
Santa Barbara Soft-shell	—	—	—	†	—

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THE LIBRARY AND READING-ROOM OF THE CENTRAL EXPERIMENT STATION.

This is an age of specialist publications, and much that is of very great value only appears in pamphlets and periodicals. The Agricultural Department receives all the publications of the experiment stations in the United States and other countries. These alone constitute a large and growing body of interesting scientific literature in many languages besides English. France, Germany, Spain, Italy, Russia, Algeria, Australia, British India, Brazil, and many other countries are represented here. Besides the reports of the stations, there are pamphlets published by various Governments, Commissions, and Departments in different countries, all bearing upon some department of agriculture. Nowhere else on the Pacific Coast can some of these publications be found on file.

Through the courtesy of editors and publishers the reading-rooms are supplied with a large number of dailies, weeklies, and monthlies, which are kept on file, and constantly referred to by students and instructors. The publications of the Department are sent in exchange, but in many cases the cost of the publications received far exceeds that of the bulletins sent out. We desire to return thanks to the kind friends who have contributed to the growth of our library and reading-room.

NEWSPAPERS RECEIVED AT STATION READING-ROOM.

CALIFORNIA.

Daily Encinal, Alameda, Alameda County.
Daily Herald, Berkeley, Alameda County.
Daily Advocate, Berkeley, Alameda County.
Washington Press, Irvington, Alameda County.
Weekly Herald, Livermore, Alameda County.
Amador Dispatch, Jackson, Amador County.
Chronicle-Record, Chico, Butte County.
Enterprise, Chico, Butte County.
Antioch Ledger, Martinez, Contra Costa County.
Contra Costa Gazette, Martinez, Contra Costa County.
Weekly Expositor, Fresno, Fresno County.
Weekly Republican, Fresno, Fresno County.
Enterprise, Ferndale, Humboldt County.
Lake County Avalanche, Lakeport, Lake County.
California Cultivator and Poultry Keeper, Los Angeles, Los Angeles County.
Rural Californian, Los Angeles, Los Angeles County.
Weekly Herald, Los Angeles, Los Angeles County.
L'Union Nouvelle, Los Angeles, Los Angeles County.

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Le Progrés, Los Angeles, Los Angeles County.
Weekly Times, Pomona, Los Angeles County.
Santa Monica Outlook, Santa Monica, Los Angeles County.
Gonzales Tribune, Gonzales, Monterey County.
Weekly Index, Salinas, Monterey County.
Weekly Register, Napa, Napa County.
Foothill Tidings, Grass Valley, Nevada County.
Truckee Semi-Weekly Republican, Truckee, Nevada County.
Press and Horticulturist, Riverside, Riverside County.
Weekly Bulletin, San Francisco.
Weekly Chronicle, San Francisco.
Weekly Examiner, San Francisco.
Weekly Post, San Francisco.
California Daily Demokrat (German), San Francisco.
The Occident, San Francisco.
California Orchard and Farm, San Francisco.
California Fruit-Grower, San Francisco.
The Monitor, San Francisco.
Pacific Rural Press, San Francisco.
Daily Weather Bulletins, U. S. Weather Bureau, San Francisco.
Dixon Tribune, Dixon, Solano County.
Chino Valley Champion, Chino, San Bernardino County.
Ontario Record, Ontario, San Bernardino County.
Orange Grower, Rialto, San Bernardino County.
Daily Courier, San Bernardino, San Bernardino County.
The Citrograph, Redlands, San Bernardino County.
Escondido Times, Escondido, San Diego County.
The Great Southwest, San Diego, San Diego County.
The Moon, Paso Robles, San Luis Obispo County.
Templeton Advance, Templeton, San Luis Obispo County.
Times-Gazette, Redwood City, San Mateo County.
Daily Independent, Santa Barbara, Santa Barbara County.
Los Gatos Mail, Los Gatos, Santa Clara County.
Daily Herald, San José, Santa Clara County.
California Prohibitionist, San José, Santa Clara County.
Fanciers' Monthly, San José, Santa Clara County.
Pacific Tree and Vine, Santa Clara, Santa Clara County.
Mountain Messenger, Downieville, Sierra County.
Petaluma Courier, Petaluma, Sonoma County.
Santa Rosa Republican, Santa Rosa, Sonoma County.
Sutter County Farmer, Yuba City, Sutter County.
Corning Observer, Corning, Tehama County.
Porterville Enterprise, Porterville, Tulare County.
Tulare County Register, Tulare, Tulare County.
Tulare County Times, Tulare, Tulare County.
Ventura Free Press, Ventura, Ventura County.
Four Corners, Wheatland, Yuba County.

OTHER STATES.

Florence Herald, Florence, Alabama.
Daily Herald, Phœnix, Arizona.
Field and Farm, Denver, Colorado.

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Florida Agriculturist, DeLand, Florida.
Florida Farmer and Fruit-Grower, Jacksonville, Florida.
Monthly Florida Bulletin, Tallahassee, Florida.
Southern Farmer, Athens, Georgia.
Southern Cultivator and Dixie Farmer, Atlanta, Georgia.
American Florist, Chicago, Illinois, and New York.
Farm and Home, Chicago, Illinois, and Springfield, Massachusetts.
Farm, Field, and Fireside, Chicago, Illinois.
Farmers' Review, Chicago, Illinois.
Irrigation Age, Chicago, Illinois.
Hotel World, Chicago, Illinois.
Orange-Judd Farmer, Chicago, Illinois.
Prairie Farmer, Chicago, Illinois.
The Farmer's Magazine, Springfield, Illinois.
Clover Leaf, South Bend, Indiana.
Home and Farm, Louisville, Kentucky.
The Louisiana Planter, New Orleans, Louisiana.
Baltimore Weekly Sun, Baltimore, Maryland.
Maryland Farmer, Baltimore, Maryland.
American Cultivator, Boston, Massachusetts.
The Farm Poultry Monthly, Boston, Massachusetts.
New England Farmer, Boston, Massachusetts.
American Cheesemaker, Grand Rapids, Michigan.
Corner Stone, Lansing, Michigan.
Grange Visitor, Lansing, Michigan.
National Dairyman, Kansas City, Missouri.
Colman's Rural World, St. Louis, Missouri.
Hospodar (Bohemian), Omaha, Nebraska.
Mirror and Farmer, Manchester, New Hampshire.
Southwestern Farm and Orchard, Las Cruces, New Mexico.
Stock-Grower, Las Vegas, New Mexico.
Weekly New Mexican Review, Santa Fe, New Mexico.
Brooklyn Grocers' Gazette, Brooklyn, New York.
American Agriculturist, New York City, New York.
Irrigation Market, New York City, New York.
Mercantile and Exchange Advocate, New York City, New York.
Rural New Yorker, New York City, New York.
Scientific American, New York City, New York.
Weekly Tribune, New York City, New York.
Green's Fruit-Grower, Rochester, New York.
Vick's Illustrated Monthly Magazine, Rochester, New York.
American Bulletin and Scientific Farmer, Cincinnati, Ohio.
American Farmer and Farm News, Springfield, Ohio.
Farm and Fireside, Springfield, Ohio.
Womankind, Springfield, Ohio.
North Pacific Rural Spirit, Portland, Oregon.
Northwest Pacific Farmer, Portland, Oregon.
The Rural Northwest, Portland, Oregon.
Germantown Telegraph, Germantown, Pennsylvania.
Meehan's Monthly, Germantown, Pennsylvania.
Farm Journal, Philadelphia, Pennsylvania.
Ladies' Home Companion, Philadelphia, Pennsylvania.
Practical Farmer, Philadelphia, Pennsylvania.

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The Sugar Beet, Philadelphia, Pennsylvania.
The Cotton Plant, Columbia, South Carolina.
Texas Farm and Ranch, Dallas, Texas.
Texas Stockman, San Antonio, Texas.
American Farm and Horticulturist, Richmond, Virginia.
Holstein-Fresian Register, Battleboro, Vermont.
The Ranch, North Yakima, Washington.
Daily Post-Intelligencer, Seattle, Washington.
Northwest Horticulturist, Tacoma and Seattle, Washington.
Hoard's Dairyman, Fort Atkinson, Wisconsin.

FOREIGN.

Agricultural Gazette of New South Wales, Sydney, N. S. W., Australia.
Garden and Field, Adelaide, S. A., Australia.
Tiroler Landwirthschaftliche Blætter, St. Michele, Austria.
Le Bas-Rhône, Paris, France.
Revue des Sciences Naturelles Appliquées, Paris, France.
Revue de Viticulture, Paris, France.
Deutsche Landwirthschaftliche Presse, Berlin, Germany.
La Agricultura, Guatemala.
Bolletino Mensile di Bachicoltura, Padova, Italy.
Bolletino dei Viticoltori Italiani, Rome, Italy.
Kongl. Landt-Bruks Akadamiens Handligar och Tedskrift, Stockholm, Sweden.

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AGRICULTURAL EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

For the Fiscal Year 1892-3.

		Cr.	Dr.
1893.			
	To receipts from the Treasurer of the United States, as per appropriation for year ending June 30, 1893, under Act of Congress approved March 2, 1887		$15,000 00
June 30—By buildings	Led., p. 2	$696 17	
By furniture	Led., p. 32	289 50	
By freight and expressage	Led., p. 53	219 58	
By incidental expenses	Led., p. 63	148 54	
By labor	Led., p. 73	5,156 04	
By postage and stationery	Led., p. 102	148 47	
By salaries	Led., p. 123	5,787 02	
By supplies	Led., p. 134	1,407 59	
By tools, implements, and machinery	Led., p. 153	289 39	
By traveling	Led., p. 163	438 35	
By water supply	Led., p. 173	519 35	
Totals		$15,000 00	$15,000 00

We, the undersigned, duly appointed members of the Finance Committee of the Regents of the University of California, do hereby certify that we have examined the books and accounts of the Experiment Stations of the University of California, for the fiscal year ending June 30, 1893; that we have found the same well and correctly kept and classified as above, and that the receipts for the time named are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
ALBERT MILLER,
I. W. HELLMAN,
Finance Committee of the Regents of the University of California.

I hereby certify that the foregoing statement, to which this is attached, is a true copy from the books of account of the institution named.

J. J. HERR,
Auditor.

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AGRICULTURAL EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

For the Fiscal Year 1893–4.

		Cr.	Dr.
1894.			
	To receipts from the Treasurer of the United States, as per appropriation for year ending June 30, 1894, under act of Congress approved March 2, 1887		$15,000 00
June 30—By buildings	Led., p. 2	$379 10	
By furniture	Led., p. 33	40 10	
By freight and expressage	Led., p. 53	399 96	
By incidental expenses	Led., p. 63	75 31	
By labor	Led., p. 74	4,284 33	
By postage and stationery	Led., p. 103	256 80	
By salaries	Led., p. 124	5,799 96	
By supplies	Led., p. 134	2,909 11	
By tools, implements, and machinery	Led., p. 153	323 53	
By traveling	Led., p. 163	352 70	
By water supply	Led., p. 173	179 10	
Totals		$15,000 00	$15,000 00

We, the undersigned duly appointed members of the Finance Committee of the Regents of the University of California, do hereby certify that we have examined the books and accounts of the Experiment Stations of the University of California, for the fiscal year ending June 30, 1894; that we have found the same well and correctly kept and classified as above, and that the receipts for the time named are shown to have been $15,000 and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
ALBERT MILLER,
ISAIAS W. HELLMAN,
Finance Committee of the Regents of the University of California.

I hereby certify that the foregoing statement to which this is attached is a true copy from the books of account of the institution named.

JOHN J. HERR,
Auditor.

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